

# EFFECT OF MAGNETIC IRRIGATION WATER AND SOIL CONDITIONERS ON SANDY SOIL PROPERTIES UNDER SALINE STRESS CONDITIONS

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## Abstract

Salinity is one of the most important threats to agriculture especially in Sinai. So, this study was carried in North Sinai for one season to evaluate the effects of Magnetite Iron soil conditioners with and without magnetic water irrigation on Date Palm tree under salt stress conditions. There is not much research carried out the combination effects of magnetic water and Magnetite Iron as a soil amendment to improve soil properties and crop yield under saline conditions at North Sinai, Egypt. The treatment of Magnetite or Magnetic Iron was 0, 300, 550 and 800 gm/tree with and without magnetic water irrigation. From the results, the best treatment was 800gm/tree magnetite iron with magnetic water which decrease EC, SAR and pH by 14 %, 5% and 2% consequently. On the other hand, it was improved soil properties such as OM and CEC as follow 29 % and 31% consequently. The macronutrient (N, P, and K) was increased by 40%, 14% and 7% consequently when compared with nonmagnetic water. Also, there was increased soil content of micronutrients (Zn, Mn, Fe, and Cu) as follow 20%, 12.5%, 22% and 17% consequently when compared with nonmagnetic water. In addition, it is consequently enhanced yield components compared with nonmagnetic water irrigation which increased by 60%.

**Keywords:** Magnetite soil application, Soil salinity, relative yield, soil properties, soil nutrients.

## INTRODUCTION

The world population is expected to increase from 7.2-9.2 billion in 2050, that's occurred in developing country (Lal and Stewart 2012). Therefore, changing climate affects human and it refer to all changes in the climate system involving the drivers of change and their impacts (Dadamouny and Schnittler 2015). Sinai Peninsula and Suez Canal corridor will be one of the economically promising areas in Egypt for agricultural extension due to the high availability of many natural resources (Roushdi et al 2016). The development in it depending on water of El Salam canal and underground water (Roushdi et al 2016 and Sharkawy et al 2010). It is located in the arid belt of North Africa and South Asia; its area is about 61000km<sup>2</sup> (Sharkawy et al 2010). Salinity is one of the most important threats to agriculture especially in Sinai (Morcillo and Manzanera 2021). According to Pachauri et al (2014) reported that land affected by salinity is rably increasing due to different factors. Therefore, the heat stress caused by climatic change diminish groundwater which accumulating salt concentration in soils (FAO Aquastat 2019). In this context, moderate salinity (EC 4-8 dS/m) may cause 50-80% reduction in crop yield depending on the plant species (Morcillo and Manzanera 2021). Due to plant roots absorb essential nutrients as soluble salts, however, excessive accumulation of salts compromises (Morcillo and Manzanera 2021). From the above-mentioned, some researchers reported that Magnetite or Magnetic Iron (M. Fe) could improve soil structure, organic matter, cations exchange capacity, water properties and consequently affecting on plant growth. M. Fe

become more energy and vigor which is known “Magneto biology” that helps to moderation of soil temperature, improving water holding capacity and crop nutrition. Besides, the magnetic instrument isolates all chlorine, unsafe gases from soil, which expanded salt development and dissolvability of nutrients (Abo-Gabien et al 2020 and Mohamed and Sherif 2020). Also, There are three primary watched impacts of magnetic water (MW) in soil 1- removal of excess soluble salts from irrigation water, 2- bringing down of pH esteems, and 3- the dissolving of slightly soluble components such as phosphates, carbonates, and sulphates (Mohamed and Sherif, 2020). Moreover, the attractive strategy of magnetic method for saline water is allegedly a successful technique for soil desalinization and it leads to modifications of its properties. So, it becomes more energetic and more able to flow which can be considered as a birth of new science called Magneto biology (Mostafazadeh et al. 2011, Fard et al. 2011 and Fanous et al. 2017). There is not much research carried out the combination effects of magnetic water and magnetic iron as a soil amendment to improve soil properties and crop yield. Thus, the aim of this research experiment was evaluate the potential effect of magnetic iron as a soil amendment and magnetic water on improve soil properties and productivity under saline conditions at North Sinai, Egypt.

## MATERIALS AND METHODS

A field experiment was achieved at Baloza, North Sinai located at 31 3' 0" N, 32 36' 0" E. This study conducted the effect of magnetite soil application with and without magnetic water of irrigation on Date Palm tree in season 2020. They were irrigated by drip irrigation system. The experimental treatments were establishment split-split plot experimental design. The main plot was the soil irrigated by with and without magnetic water and subplots were treated with application of magnetic iron (300-550-800 gm/tree) with three replicates. Magnetite was obtained from “Al-Ahram Company for Mining and Natural Fertilizers” (ECMNF), Giza, Egypt, Different magnetite levels were added once in the winter (January) around the trees.

**Fig (1): Location map of the studied area at Sinai, Egypt**



### Soil sampling and analysis:

- Soil samples were collected at triplicate at 0-30 cm depth from selected trees by soil auger. These disturbed soil samples were air dried, crushed and passed through 2 mm sieve and prepared for soil analysis. The undisturbed soil samples were collected to determine chemical

and physical properties such as Particle size distribution was carried out using the pipette method as described by Klute (1986). Sodium hexameta phosphate was used as dispersing agent, (Kilmer and Alexander 1949). Bulk density (Db) was determined on the undisturbed soil cores as described by Klute (1986). Saturated soil extract 1:2.5 was prepared. The extracted extract was analyzed according to Richards (1954) to determine: The electrical conductivity (EC) in dS/m using a conductivity meter as described by Black, (1965). Soil (pH) was determined in 1:2.5 (w/v) soil suspensions using a Beckman bench type pH meter, (USDA, 1954). Soluble cations and anions in mmolc/L were determined according to the methods as described by Jackson, (1973). Total calcium carbonate (CaCO<sub>3</sub>) was determined using the Collin's calcimeter (Black, 1965). Organic matter content was determined according to Walkley and Black procedure as lined out by Jakson (1967). Cation exchange capacity (CEC) was determined using ammonium acetate (NH<sub>4</sub>OAc) method as mentioned by Bower and Gschwend (1952), and exchangeable sodium percentage (ESP) was determined using ammonia acetate solution (NH<sub>4</sub>OAC), Bower and Gschwend (1952). Otherwise, the available nutrient of micronutrients were Zn, Mn, Fe and Cu were extracted according to the method of Soltanpour (1991). Some physical properties of initial soil are shown in Table 1. The soil is sandy loam in texture and highly calcium carbonate.

**Table 1. Some physical properties of soil surface (0-30) at studied area.**

Soil depth	Particle Size distribution (%)			Texture class	CaCO <sub>3</sub> (%)	BD
	Sand	Silt	Clay			
0-30	89.12	6.34	4.54	Sandy	37.8	1.24

BD: Bulk Density and OM: Organic Matter.

### Water analysis:

Irrigation water was trickle irrigation from well. Irrigation water source was magnetized by passing magnetic field Magnolith (EWL umelttechnik GMBH, German) permanent magnets with north and south poles 88 cascaded magnetic field. The strength of this magnetic field ranged between 2000-4000 Gauss. The device consisted of two parts, attached to an irrigation pipe with its internal diameter of 3inches. The chemical properties of the irrigation water are shown in table 2.

**Table 2. Chemical properties of the studied irrigated water**

Magnetic treatment	pH	EC (dS/m)	Cations (me/L)				Anions (me/L)				SAR
			Ca	Mg	Na	K	CO <sub>3</sub>	HCO <sub>3</sub>	Cl	SO <sub>4</sub>	
Nonmagnetic water	6.4	9.19	16.65	10.25	82.14	2.3	0	2.24	90.32	19.12	2.16
Magnetic water	6	8.12	14.2	11.3	70.02	3.1	0	1.23	87.24	10.23	1.94

SAR: Sodium adsorption ratio.

### Relative yield:

The crop yield in each treatment at harvest time was determined by average bunch weight were recorded and palm yield were calculated as follows:

$$Y_r = \frac{\text{Mean estimated yield of the cultivated crop}}{\text{The recorded maximum yield of the same crop at studied area}} \times 100$$

### Statistical analysis:

The obtained data for the two seasons were statistically analyzed using the Computer Program, SAS (2003), the significant differences among treatments means were evaluated by Duncan's Multiple Range-Test (Duncan, 1955).

## RESULTS AND DISCUSSION

### Soil salinity (ECe) and sodicity:

The application of magnetic water under trickle irrigation and magnetic iron alone or combination with each other, were highly significant ( $p < 0.05$ ). It was effect on decreasing soil salinity and soil sodicity. Which, soil salinity indicated by electrical conductivity (ECe) dS/m and soil sodicity indicated by sodium adsorption ratio (SAR) of soil was highly significant ( $p < 0.05$ ) with treatments as show in fig 2 and 3. Moreover, results varied from 9.3-4.29 dS/m and 8.89 -3.66 dS/m for treatment with nonmagnetic water and with magnetic water consequently. On the other hand, SAR value or sodicity varied from 23.67-11.31 and 19.61-10.79 for treatment with nonmagnetic water and with magnetic water consequently. Soil salinity and sodicity as affected by treatments can be arranged in descending order control  $> 300 > 550 > 800$  gm /tree. Which decreased about 52% and 45% for 800 gm/tree M.Fe with nonmagnetic water and with magnetic water, consequently. This data aligns with Mostafazadeh et al 2012 and Fanous et al 2017, Sarwar et al 2008 and Amer et al 2016. Moreover, that is decrease effect because of the Na element is a paramagnetic element which have a small positive susceptibility to magnetic field as reported by Fanous et al 2017. Also, it may cause by the effect of solubility of NaCl and Na<sub>2</sub>CO<sub>3</sub> salts in magnetized water and the latter can use for leaching the salts away from roots zone as proposed by Hilal et al 2012. On the other hand, the effect of magnetic iron caused more decrease in soil salinity due to sorb salts and mitigate of salt stress of the soil and the same time oxygen concentration was increased that is through its influenced-on hydrogen bonds as reported by Abobatta 2015 and Abo Gabin et al 2020.

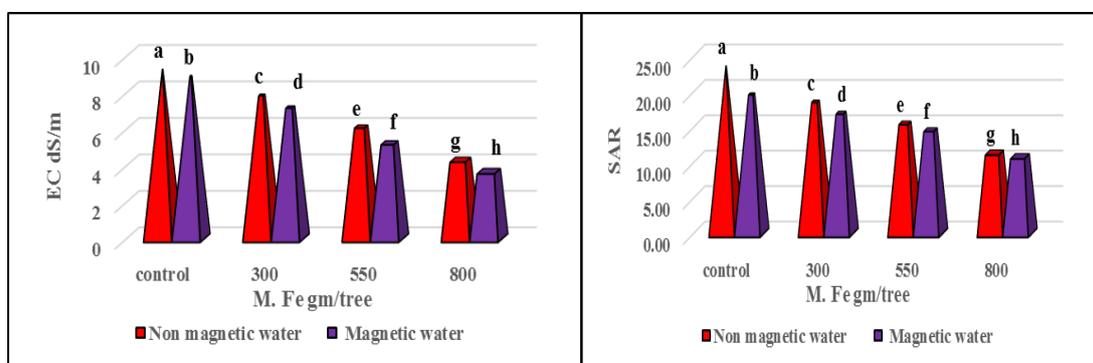
### Soil pH and soil cation exchange capacity (CEC):

The results Soil pH and CEC as shows in fig. 4 and 5 were highly significant ( $p < 0.05$ ). From the results in fig 2 and 3, the best treatments effect decreased pH and increased CEC was 800 gm /tree magnetic iron with magnetic water decreased pH about 40% and increased CEC about 20%. This result agreement with Mohammed 2013, Fanous et al 2017, Zlotopolski 2017, Abo Gabien et al 2020 and Mohamed and Sherif 2020. Due to, increase the effect of magnetic field on organic matter in the soil where it releases relatively greater of organic acids in rhizosphere reported by Fanous et al 2017. Also, CEC increased due to decreasing pH as the variable charge

surfaces become more positively charged due to protonation of functional groups as reported by Sparks 2003. Thus, CEC acts to buffer the acidity of many temperate soils. When H<sup>+</sup> is added to the soil solution, it exchanges for cations, on clay minerals and organic matter as reported by William et al. 2020.

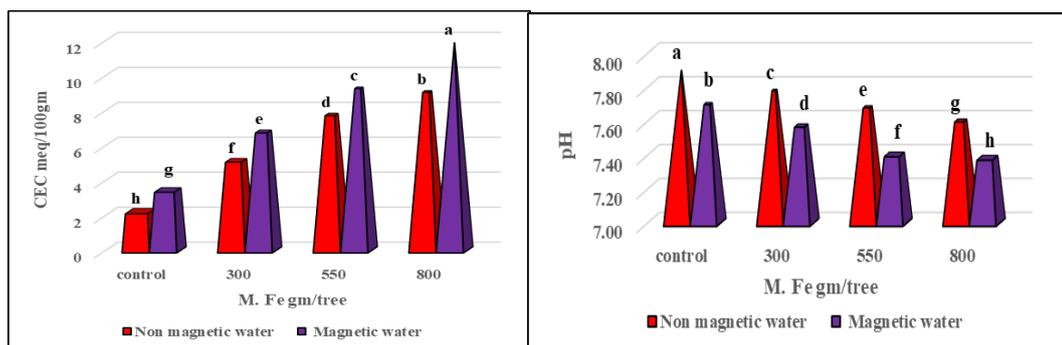
**Fig. (2):** Effect of Magnetic treated water (MTW) and magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on EC dS/m Values followed by different letters are significantly at  $p < 0.05$ .

**Fig. (3):** Effect of Magnetic treated water (MTW) and magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on SAR Values followed by different letters are significantly at  $p < 0.05$ .



**Fig. (4):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 550 and 800 gm/tree) on CEC meq/100gm, values followed by different letters are significantly at  $p < 0.05$ .

**Fig. (5):** Effect of Magnetic treated water (MTW) and magnetic Fe (M. Fe) (control, 300, 550 and 800 gm/tree) on pH, values followed by different letters are significantly at  $p < 0.05$ .



It is defined as CEC cation exchange capacity

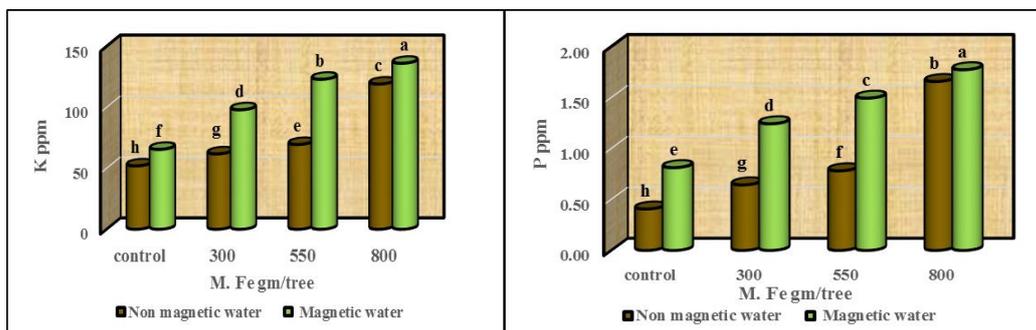
**Organic matter and soil macronutrients:**

The results of effect of treatment on soil organic matter (SOM) and macro nutrients (N, P and k) were presented in fig 6, 7, 8 and 9. The statistical analysis results were highly significant

( $P < 0.05$ ). The results clarify, SOM increased in ascending order as follow control > 300 > 550 > 800 gm/tree in with and without magnetic water. Which varied from 0.02%-0.05%, 0.03%-0.07% for without and with magnetic water consequently. So, the best treatment was 800 gm/tree with magnetic water. Furthermore, the effect of magnetic water and magnetic iron have effect to increase soil organic matter and macronutrients. Due to, increased oxygen concentration and that is through magnetic field influenced-on hydrogen bonds and van der waals forces. Which leading to defect in the hydrogen and non-hydrogen bonds. On the other hand, this leads to the tightening and spacing of the hydrogen bonds. Moreover, its dissolution of gases in water, where the proportion of gases increases, especially oxygen gas. Therefore, increasing the concentration of oxygen, soil moisture and soil temperature, which leads to exert strong control on the rate of soil organic matter (SOM) decomposition. On the other hand, the results of macronutrient (N, P, K) shown in fig. 7, 8 and 9 were significantly ( $P < 0.05$ ). the results were varied from 0.02%-0.05% and 0.03%-0.07%, 51.94ppm-119.06 ppm and 65.48ppm-136.11 ppm, 0.41ppm-1.66ppm and 0.81ppm-1.77 ppm for TN, Av. K and Av. P with and without magnetic water consequently. There was increased in magnetic iron treatment with magnetic water when compared with treatments without magnetic water by average 40%, 14% and 7% for TN, Av. K and Av. P, consequently. Because of, decrease pH and available amount of all the macro nutrients increased in soil by increasing the acid as reported by Sarwar et al 2008 Abobatta 2015, Neira et al 2015, Amer 2016, Sierra et al 2017 and Abo Gabin et al 2020. Also, according to Hilal et al 2012 pointed out that magnetized water prevents harmful metals such as, Lead and Nickel, from uptake by roots and reaching fruits and roots. However, it increases the percentage of nutrient elements like Phosphorus and Potassium.

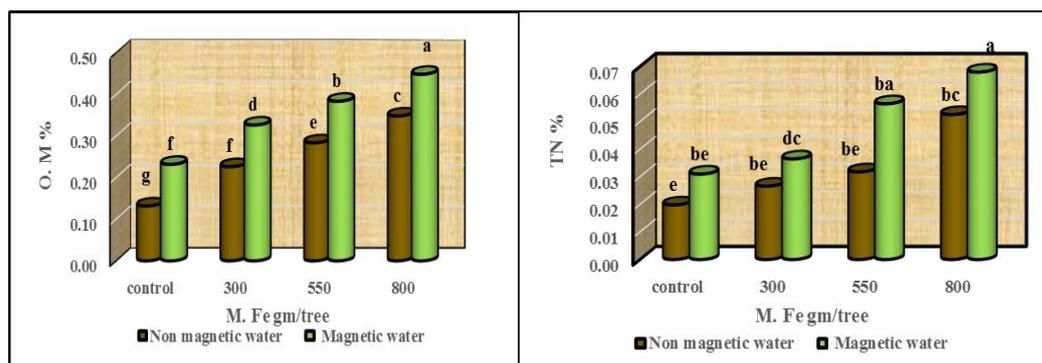
**Fig. (6): Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on OM%, values followed by different letters are significantly at  $p < 0.05$ .**

**Fig. (7): Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on TN%, values followed by different letters are significantly at  $p < 0.05$ .**



**Fig. (8):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on K ppm, values followed by different letters are significantly at  $p < 0.05$ .

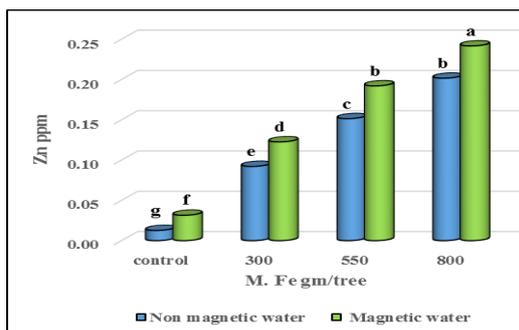
**Fig. (9):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) ( control, 300, 500 and 800 gm/tree) on P ppm, values followed by different letters are significantly at  $p < 0.05$



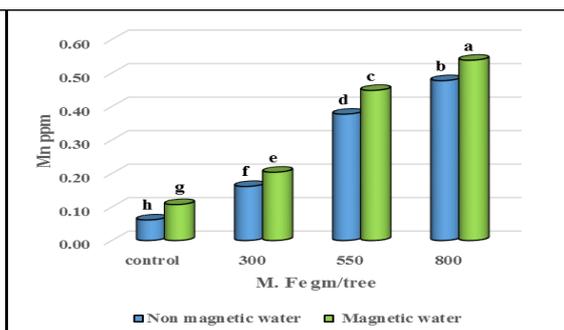
### Soil Micronutrient:

The results in Fig. (10, 11, 12 and 13) show the micronutrients Zn, Mn, Fe and Cu mg/kg in experimental soil. The effect of MW and M. Fe gave significant values ( $P < 0.05$ ) of all micronutrients. The order of result was as descending order as follow 800>550>300>control gm/tree with MW and without MW. The results were varied from 0.01-0.20 ppm and 0.03-0.24 ppm, 0.06-0.48 ppm and 0.11-0.54 ppm, 0.06-0.23 ppm and 0.10-0.28 ppm, 0.02-0.12 ppm and 0.03-0.14 ppm for Zn, Mn, Fe and Cu without and with magnetic water, consequently. Obviously, the availability of micronutrients increased with increased addition rate of magnetic iron and more increased with magnetic water. These results agreement with Hilal et al 2012 and Mohamed and Sherif 2020. Because of, the role of treatments of M. Fe as soil amendments with MW reflects on the retention and mobilization of existing nutrients for plants uptake improving soil function by reducing nutrient loss below the root zone as well as increasing the bioavailability of nutrients of plants. Sarwar et al 2008 reported that, the increase of mobility of micronutrients in the root zone caused by magnetic susceptibility for each element.

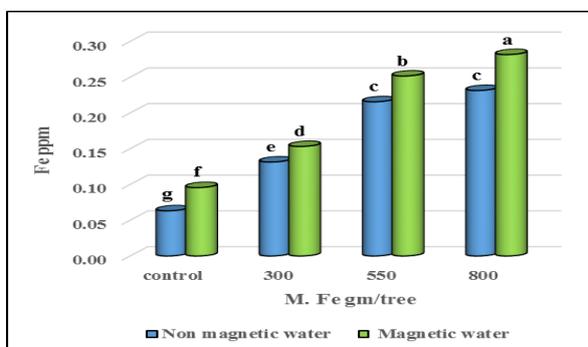
**Fig. (10):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on Zn ppm, values followed by different letters are significantly at  $p < 0.05$ .



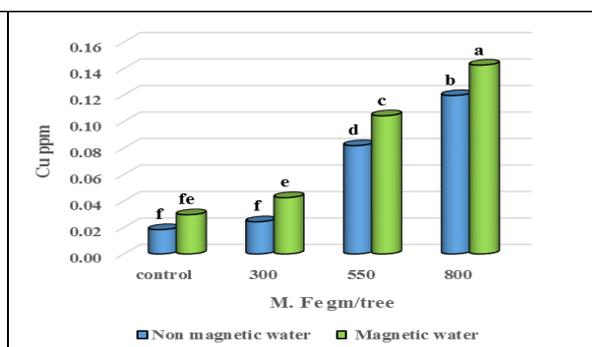
**Fig. (11):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on Mn ppm, values followed by different letters are significantly at  $p < 0.05$ .



**Fig. (12):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on Fe ppm, values followed by different letters are significantly at  $p < 0.05$ .



**Fig. (13):** Effect of Magnetic treated water (MTW) and Magnetic Fe (M. Fe) (control, 300, 500 and 800 gm/tree) on Cu ppm, values followed by different letters are significantly at  $p < 0.05$ .

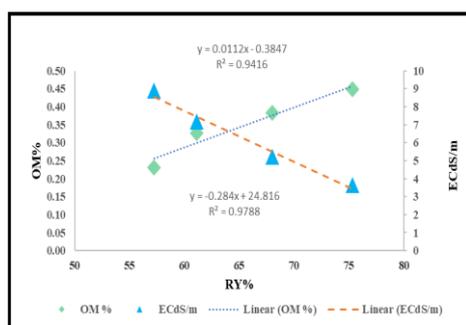


From the abovementioned, Magnetic water physically treats irrigation water and the salts in it, which increases its quality. On the other hand, the magnetic field helps activate aerobic bacteria in the soil, which in turn decomposes organic matter and increases the availability of elements. Also, this is in addition to its mechanical effect on the absorption of elements by the plant roots through its effect on reducing the surface tension coefficient of water, which increases the soil permeability coefficient for water, and the melting of salts occurs and the elements are more readily available Hilal et al 2012.

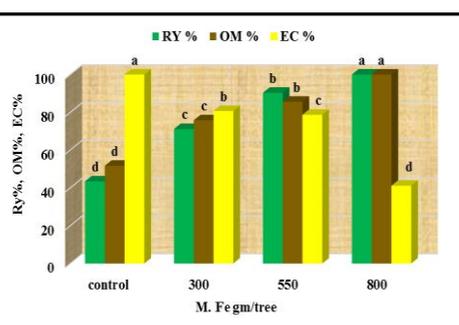
### Relative Yield (RY):

The ameliorative role of the previous amendments in salt affected soils may be attributed to these materials increase the tolerance of plants to salinity at physiological growth stages through improved soil properties. Similar results were showed by Amer 2016, and Abo Gabian et al 2020. Obviously, the organic matter has a positive influence on nutrient availability and several soil processes by motivate soil microorganisms' activity. Because of its effect on decrease pH, EC and subsequently increase the availability of nutrients (Wassif 2010). Subsequently, it is the most important indicators of crop productivity. Hence, there was a relationship between organic matter, soil salinity and yield or crop production of Date Palm tree as shown in fig. 14. There was a negative relationship with highly significant ( $p < 0.05$ ) between relative yield (RY %) and ECe dS/m. When increased ECe i.e., 8.89 dS/m the crop yield decreased i.e., 57.25%. Vice versa, when ECe was decreased i.e., 3.6 dS/m the Ry was increased i.e., 75.3%. On the other hand, there is a positive relationship between RY% and OM% with highly significant ( $p < 0.05$ ). Therefore, the OM decreased 0.23% the RY was decreased 57.25 % but when increased OM 0.45% the RY increased 75.3%. On the other hand, there is indirect positive effect of treatments of magnetic iron and magnetic water on crop production of date palm tree through its positive effect on soil salinity and organic matter and thus follows positive effect on improving availability of nutrients to plants as shown in fig. 15. These results agreement with Hamdy et al 2015, Fanous et al 2017 and Abo Gabian et al 2020.

**Fig (14): Relationship between soil organic matter (SOM %), Electric conductivity (EC%) and Relative yield (RY%) calculated based on effect of treatment of magnetite iron (control, 250,500,750 gm/tree) with magnetic water.**



**Fig. (15): Effect of OM % and EC% under treated by magnetic water (MW) and Magnetic Fe (M. Fe) (gm/tree) on relative yield (RY %), values followed by different letters are significantly at  $p < 0.05$ .**



### CONCLUSION

In conclusion, magnetic Fe with magnetic water irrigation has improved soil properties (EC, SAR, pH, CEC, OM, macronutrients and micronutrient) and yield production quality. The treatment of 800 g/tree magnetic iron with magnetic water irrigation was the most effective for Date Palm under North Sinai conditions as compared with the control. Magnetized water

improved the efficiency of the soil amendments by physically treats of salt in the saline irrigation water and increases its quality. On the other hand, the magnetic field helps activate aerobic bacteria in the soil, which in turn decomposes organic matter and increases the availability of elements. This study recommended to use magnetite as 800 gm/tree with magnetic water technic which have a satisfying result to combat the climate change risks.

## REFERENCES

- Abobatta, W. F. (2015).** Influence of Magnetic Iron and K-Humate on Productivity of Valencia Orange Trees (*Citrus Sinensis L.*) under Salinity Conditions International Journal of Scientific Research in Agricultural Sciences, 2(Proceedings), pp. 108-119, 2015 Available online at <http://www.ijsrpub.com/ijrsras> Conference organizer retains the copyright of this article
- Abo-Gabien, M.G., A. R. Atawia, H. E. M. El-Badawy, S. F. El-Gioushy and S. M. Bakeer, (2020).** Effect of Magnetic Iron and Potassium Humate on Some Flowering and Fruiting Aspects of Olive Trees under Salt Stress Conditions in South Sinai 5th International Conference on Biotechnology Applications in Agriculture (ICBAA), Benha University, Hurghada, 8-11, Egypt DOI: 10.13140/RG.2.2.21076.96645
- Amer, M. M., (2016).** Effect of Biochar, Compost Tea and Magnetic Iron Ore Application on some Soil Properties and Productivity of Some Field Crops under Saline Soils Conditions at North Nile Delta Egypt. J. Soil Sci. Vol.56, No.1, pp.169-186. doi: 10.21608/EJSS.2017.1097
- Dadamouny M.A. and M. Schnittler (2015).** Trends of climate with rapid change in Sinai, Egypt. J. Water and climate change doi:10.2166/wcc2015.215.
- Duncan, D. B., (1955).** Multiple range and multiple F- test. Biometrics, 11: 1-42. <https://doi.org/10.2307/3001478> <https://www.jstor.org/stable/3001478>
- FAO AQUASTAT (2019).** FAO's Information System on Water and Agriculture: Climate information tool. AQUASTAT Climate characteristic <http://www.fao.org/nr/water/aquastat/main>
- Fanous, N.E., Amira A. Mohamed and Kh. A. Shaban, (2017).** Effect of Magnetic Treatment for Irrigation Ground Water on Soil Salinity, Nutrients, Water Productivity and Yield Fruit Trees at Sandy Soil Egypt. J. Soil Sci. Vol. 57 No. 1, pp.113-123. DOI: 10.21608/EJSS.2017.1528
- Fard B. M.; M. Khoshravesh; S. F. Mousavi; and A. R. Kiani (2011).** Effects of Magnetized Water and Irrigation Water Salinity on Soil Moisture Distribution in Trickle Irrigation Vol. 137(6):398–402. Doi:epdf/10.1061/%28ASCE%29IR.1943-4774.0000304
- Hamdy, A.E., S.M. Khalifa and S.A., Abdeen (2015).** Effect of magnetic water on yield and fruit quality of some mandarin varieties Annals of Agric. Sci., Moshtohor 53(4): 657–666. DOI: 10.21608/assjm.2015.109942
- Hilal, M. H., Y. M., El-Fakharaniy, S.S., Mabrouk, A. I Mohamed, and B. M., Ebead, (2012).** Effect of magnetic treated irrigation water on salt removal from a sandy soil and on the availability of certain nutrients. Int. J. of Engineering and App. Sci.
- Klute, A. (1986).** Water Retention Laboratory Methods. pp. 635-661. In A. Klute (ed.) Methods of Soil Analysis. Part 1. 2nd ed. Agronomy Monogram, 9. ASA, Madison WI. <https://doi.org/10.2136/sssabookser5.1.2ed.c26>
- Lal, Rattan and B.A. Stewart (2012)** Soil Water and Agronomic Productivity book 1st Edition 594 Published by CRC Press Pages 203 B/W Illustrations.
- Morcillo, R.J. L. and Manzanera, M. (2021).** The Effects of Plant-Associated Bacterial Exopolysaccharides on Plant Abiotic Stress Tolerance Metabolites. <https://doi.org/10.3390/metabo11060337>
- Mohamed A. I. (2013).** Effects of Magnetized Low-Quality Water on Some Soil Properties and Plant Growth 3(2):140-147.

- Mohamed A., S., and A. E. A. Sherif, (2020).** Effect of magnetic saline irrigation water and soil amendments on growth and productivity of Kalamata olive cultivar Egypt. *J. Agric. Res.*, 98 (2), 302-326. Roots and Nutrient Distribution under Drip Irrigation and Yield of Faba Bean and Onion
- Mostafazadeh, F., B., Khoshravesh, M., Mousavi, S.F. and Kiani, A.R. (2011).** Effects of magnetized water on soil sulfate ions in trickle irrigation. In Proceedings of the second international conference on environmental engineering and applications IPCBEE, Vol.17.Singapore.
- Mostafazadeh, F., B.; M. Khoshravesh; S. F. Mousavi; and A. R. Kiani, (2012).** Effects of Magnetized Water on Soil Chemical Components underneath Trickle Irrigation 138(12) 1075-1081. DOI: 10.1061/(ASCE)IR.1943-4774.0000513
- Neira J., M. Ortiz, L. Morales, and E. Acevedo (2015).** Oxygen diffusion in soils: Understanding the factors and processes needed for modeling chilean journal of agricultural research 75 (Suppl. 1). <http://dx.doi.org/10.4067/S0718-58392015000300005>
- Pachauri, R.K.; Allen, M.R.; Barros, V.R.; Broome, J.; Cramer, W.; Christ, R.; Church, J.A.; Clarke, L.; Dahe, Q.; Dasgupta, P.; (2014)** Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Pachauri, R., Meyer, L., Eds.; IPCC: Geneva, Switzerland, p. 151. <https://epic.awi.de/id/eprint/37530/>
- Page, A. L., R.H. Miller, and D. R. Keeny (1982).** Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Agron. Monograph No. 9 ASA. Madison, WI, USA DOI: 10.4236/oalib.1100971
- Roushdi, M., H., Mostafa and K. Kheireldin (2016)** present and future climate extreme indices over Sinai Peninsula, Egypt. *International scholarly and scientific research and innovation* 10(1) 87-90.doi: 10.2166/wcc2015.215
- Sarwar, G., H., Schmeisky, N. Hussain, S. Muhammad, M. Ibrahim, and Ehsan Safdar, (2008).** Improvement of soil physical and chemical properties with compost application in. rice-wheat cropping system. *Pak. J. Bot.*, 40(1), 275-282.
- SAS (2003).** Statistical Analysis System, User's Guide, Statistics, SAS Institute Carry, North Carolina
- Sharkawy, S.F.T; A.H. El-Flah and M. H. Ali (2010)** Monitoring and evaluating erosion and deposition rates by wind in some areas in Sinai J. Zagazig uni. *Egypt. J. of Appl. Sci.*, 29 (8) 869-892.
- Sierra, C. A., S. Malghani, and H. W. Loescher (2017).** Interaction's moong temperature, moisture, and oxygen concentrations in controlling decomposition rates in a boreal forest soil *Bio geoscience*, 14, 703–710. <https://doi.org/10.5194/bg-14-703-2017>
- Soltanpour, P.N., (1991).** Determination of nutrient availability element toxicity by AB-DTPA. *Soil Test and ICPS Adv. Soil Sci.*, 16: 165- 190. doi: 10.1007/978-1-4612-3144-8
- Sparks, D. L., (2003).** Ion Exchange Process chapter in *Environmental Soil Chemistry* book (second edition). ISBN 9780080494807 Edition – Elsevier <https://www.elsevier.com/books/sparks>
- Wassif, Omnia M., (2010).** Evaluation of some soil degradation factors in El-Fayoum governorate – Egypt. Masters in agriculture science (soil science); Department of soil science Fac. of Agri., Zagazig Univ., Benha Branch Uni.
- William H., W. H. Schlesinger, E. S. Bernhardt, (2020).** The lithosphere chapter in *Biogeochemistry* (fourth edition).
- Zlotopolski, V. (2017).** The Impact of magnetic water treatment on salt distribution in a large unsaturated soil column, *International Soil and Water Conservation Research*, 5:253– 257. <https://doi.org/10.1016/j.iswcr.2017.05.009>.