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Advancements in magnetized water technology: Enhancing crop yields, drought tolerance, and environmental sustainability: A review

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MAGNETIZED water technology, which involves treating water by passing it through a magnetic field, has gained significant attention for its wide-ranging applications in agriculture, industry, and environmental management. This innovative approach modifies the physical and chemical properties of water, enhancing its utility in various sectors. In agriculture, magnetized water has been shown to improve crop yields, soil quality, and water use efficiency, particularly in arid and semi-arid regions. Studies from countries like India, Brazil, and China demonstrate that magnetized water irrigation increases soil moisture retention, reduces salinity, and enhances drought tolerance in crops such as sugarcane, wheat, and rice. Additionally, it promotes nutrient uptake, seed germination, and overall plant growth by activating enzymes and improving photosynthetic efficiency. In the industrial sector, magnetized water has proven effective in reducing energy consumption, inhibiting scale formation, and improving wastewater treatment processes. For instance, advanced magnetic filtration systems have achieved up to 95% removal of iron oxide contaminants from industrial wastewater. The technology also supports sustainable farming practices by reducing irrigation water requirements and improving the economic efficiency of water and fertilizer use. The scientific mechanisms behind magnetized water involve the alteration of hydrogen bonds, reduction in water cluster size, and changes in viscosity and surface tension, which enhance water absorption and nutrient transport in plants. Cryptochromes, plant photoreceptors, are believed to play a role in mediating the effects of magnetic fields on plant growth and stress responses. Overall, magnetized water technology offers a cost-effective, eco-friendly solution to address global challenges such as water scarcity, soil degradation, and climate change, making it a promising tool for sustainable development.

Keywords: Magnetized water technology, Sustainable agriculture, Water use efficiency, Drought tolerance, Soil salinity reduction.

Introduction

The concept of magnetized water modification, though rooted in early scientific exploration, has seen significant advancements in recent years. Magnetized water, which is water treated by passing it through a magnetic field, has gained widespread recognition for its applications in agriculture, industry, medicine, and environmental management. Its ability to enhance crop yields, improve soil quality, and increase water use efficiency has made it a valuable tool in sustainable farming practices. Countries such as the United States, China, India, Brazil, and several European nations have increasingly adopted magnetized water technology to address challenges related to water scarcity, soil salinity, and crop productivity (Abd El-All *et al.*, 2013 and Rashidi *et al.*, 2016).

Recent studies have demonstrated that magnetized water irrigation promotes endogenous growth promoters and photosynthetic pigments, leading to improved plant growth, root development, and nutrient uptake. It also enhances soil nutrient availability, activates plant enzymes, and increases crop yields. Additionally, magnetized water has been shown to reduce sodium toxicity in plant cells by detoxifying and restricting its entry into root cell membranes (Hozayn *et al.*, 2010; Alikamanoglu and Sen, 2011; Mostafazadeh-Fard *et al.*, 2011; Radhakrishnan and Kumari, 2012; Youssef and Taha, 2016 and Mahmoud *et al.*, 2018, 2019). According to Bondarenko *et al.* (1999), the effects of magnetized water are attributed to high-energy reactions involving atomic oxygen, free radicals, and nitrogen-containing compounds. The magnetic field also redistributes energy flow by altering the momentum of charged particles, further enhancing its beneficial effects.

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In the industrial sector, magnetized water has been found to improve processes by altering water properties such as viscosity, surface tension, electrical conductivity, and pH. Esmaeilnezhad *et al.* (2017) reported that magnetized water is particularly useful in industries for scale formation inhibition and improving the efficiency of chemical processes.

Cryptochromes, blue light receptors originally discovered in Arabidopsis, play a crucial role in plant growth and development. They regulate various light responses, including circadian rhythms, tropic growth, stomatal opening, and stress responses. Maffei (2014) suggested that cryptochromes respond to magnetic fields, potentially linking magnetized water to improved plant growth and stress tolerance.

The growing body of research underscores the versatility and effectiveness of magnetized water technology. From improving crop yields and soil health to enhancing industrial processes and wastewater treatment, magnetized water is proving to be a sustainable and cost-effective solution for a wide range of applications. This review aims to provide a comprehensive overview of the latest developments in magnetized water technology, highlighting its potential to address some of the most pressing challenges in agriculture, industry, and environmental management.

1- What is the definition of magnetized water technology?

Magnetized water is that passed through the magnetic field to induce some physical or chemical changes in water and its environmentally friendly, with low installation costs and no energy requirements (Rashidi *et al.*, 2016 and Youssef and Taha, 2016).

2- Magnetized water technology effect on plant, water and soil.

2-1- Magnetized water technology effect on soil moisture, water stress, drought tolerant and water use efficiency.

It is known that water stress causes decrease in plant growth and its yield according to Addad *et al.*, 2025 and Youssef *et al.*, 2025 on wheat and Younis *et al.*, 2025 and Youssef *et al.*, 2025 on maize. Many studies conducted across various countries have demonstrated the significant benefits of magnetized water irrigation in improving soil moisture, drought tolerance, and water use efficiency. Surendran *et al.* (2016) found that irrigation with magnetized water resulted in higher soil moisture retention for 1–3 days post-treatment compared to untreated water. Similarly, Ageeb *et al.* (2018) observed that magnetized water irrigation enhanced soil moisture levels in cowpea crops, even when using saline and hard water solutions. Hasan *et al.* (2018) highlighted that magnetized water treatment improves plant drought tolerance by boosting antioxidant capacity, enabling plants to better withstand water stress. Mahmoud *et al.* (2018) reported that magnetized water techniques allowed for a 20% reduction in irrigation water usage without compromising crop production, with the potential to further increase yields. Additionally, water use efficiency and economic returns improved significantly, even with a 40% reduction in water quantity, demonstrating the potential of magnetized water to optimize high-quality water utilization.

2-2- Magnetized water technology effect on water and soil (salinity and pH).

Aly *et al.* (2015) and Mostafa *et al.* (2016) reported that magnetic treatment enhanced the leaching of excess soluble salts, reducing soil alkalinity and dissolving less soluble salts such as carbonates, phosphates, and sulfates. Similarly, Surendran *et al.* (2016) observed that magnetic treatments significantly decreased salinity levels, electrical conductivity, and total dissolved solids in irrigation water. Electron microscopy revealed changes in the calcium carbonate crystal structure under magnetic treatment, with increased crystal length compared to untreated water. These findings demonstrated the beneficial effects of magnetized water on crop growth and yield, confirming its potential for use with low-quality water in agriculture. Abedinpour and Rohani (2017) found that magnetized water irrigation increased soil electrical conductivity while reducing soil pH. Meanwhile, Liu *et al.* (2017) demonstrated that magnetic treatments reduced sodium (Na^+) content and increased the potassium-to-sodium (K^+/Na^+) ratio. The treatments also enhanced sodium efflux and hydrogen (H^+) influx while decreasing potassium (K^+) and magnesium (Mg^{++}) efflux compared to control conditions.

Nabile *et al.* (2017) further confirmed that soil salinity decreased significantly after magnetized water treatment, dropping from 4.88–6.15 dS/m to 2.73–4.15 dS/m after one month and to 1.45–2.83 dS/m after eight months. Soil pH also decreased from 8.20–8.30 to 7.90–8.05, while sodium chloride (NaCl) and magnesium chloride ($MgCl_2$) levels were reduced from 21.50–8.00 meq/L to 6.30–3.00 meq/L over eight months. Ageeb *et al.* (2018) studied cowpea and found that magnetized water irrigation reduced salinity, electrical conductivity, and total dissolved solids in irrigation water. Electron microscopy confirmed changes in calcium carbonate crystal structure, with increased crystal length under magnetic treatment. In a separate study on tomatoes, Ageeb *et al.*

(2018) observed 1.27 times greater salt accumulation in untreated soil at the surface and 1.4 times greater at 25–50 cm depth compared to magnetized water-treated soil. Sodium concentrations were 12.1% higher in untreated soil at 0–25 cm and 22.5% higher at 25–50 cm. The reduction in electrical conductivity and pH levels due to magnetized water irrigation accelerated biological activity and plant growth. Alzubaidi (2018) noted that saline water irrigation significantly reduced all studied parameters compared to distilled water, but magnetized water improved these parameters under saline conditions.

2-3- Magnetized water technology effect on the iron oxide from feed water.

Ha *et al.* (2011) demonstrated that the application of a high-intensity magnetic field effectively removed iron oxide contaminants, specifically hematite (α-Fe_2O_3) and maghemite (γ-Fe_2O_3), from water feed plant sources. This breakthrough highlighted the potential of magnetic technology in purifying water for industrial and agricultural use. Similarly, Yamamoto *et al.* (2019) developed an advanced magnetic field system capable of efficiently removing iron oxide contaminants from water feed sources, further advancing the application of magnetic filtration in water treatment.

2-4- Magnetized water technology effect on seed germination.

Mahmood and Usman (2014) demonstrated that the application of magnetized water significantly promoted the germination of maize seeds. The emergence index increased from 5.50 to 8.92, and the emergence rate index rose from 10.06 to 12.84, while the mean emergence time was reduced by 17.90% when using magnetized sewage water compared to non-magnetized water. Additionally, magnetized water treatment resulted in faster growth across all water types, with the maximum increase in seedling length and weight observed in magnetized sewage water. Similarly, Rajan *et al.* (2017) found that magnetically treated water positively impacted seed germination. Their study revealed that more seeds germinated in magnetized water compared to tap water, and the osmotic ratio was significantly higher. Furthermore, the weight of seeds increased from 2.04 grams to 4.26 grams when treated with magnetized water. Alzubaidi (2018) reported that magnetized water irrigation led to higher germination percentages, faster germination speeds, longer radicle lengths, and increased seedling weights compared to untreated controls.

2-5- Magnetized water technology effect on fertilization nutrients.

Abedinpour and Rohani (2017) demonstrated that irrigation with magnetized water significantly increased the availability of nitrogen (N) and phosphorus (P) in the soil. Similarly, Dawa *et al.* (2017) found that plants irrigated with magnetized water exhibited the highest levels of essential leaf minerals, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), and manganese (Mn), compared to those irrigated with untreated water during both study seasons. However, iron (Fe) content showed a negative response to magnetized water treatment. In another study Doklega (2017) observed that potato plants irrigated with magnetized water achieved the highest values in plant chemical composition and quality parameters, except for nitrate (NO_3) and nitrite (NO_2) contents, which were lower compared to normal water treatments. Meanwhile, Liu *et al.* (2017) reported that magnetic treatments resulted in higher potassium (K^+) and magnesium (Mg^{++}) contents, along with lower calcium (Ca^{++}) content in both roots and leaves. Additionally, Nabile *et al.* (2017) highlighted that magnetized irrigation positively influenced the availability of nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients such as iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn), leading to increased fruit yields during the fertilization season.

Ageeb *et al.* (2018) conducted a study on tomatoes and found that magnetized water irrigation improved the levels of nitrogen, potassium, phosphorus, iron, and manganese in tomato plants compared to the control. Mahmoud *et al.* (2019) revealed that the doses of nitrogen fertilization could be reduced by 20% while maintaining or even increasing crop yields when using magnetized water irrigation. The efficiency of nitrogen fertilization and the economic return per unit of nitrogen were higher, even with reduced fertilization doses. Furthermore, magnetized water irrigation increased the leaf content of nitrogen, potassium, and phosphorus.

2-6- Magnetized water technology effect on growth and growth parameters.

Hozayn *et al.* (2010) and Ali *et al.* (2011) demonstrated that magnetic treatment enhanced the availability of mobile forms of fertilizers, increased photosynthetic pigments, and activated bio-enzyme systems, leading to improved plant growth and higher crop yields. Similarly, Amer *et al.* (2014) reported that magnetic treatment positively influenced phyto-hormone production, increased mobile fertilizer forms, enhanced water absorption, improved moisture content, and boosted photosynthetic pigments. These effects were attributed to the activation of endogenous promoters like indole-3-acetic acid (IAA), which enhanced cellular activity. Maffei (2014) further explained that cryptochromes (CRY), photosensory receptors in plants, regulate growth, development, and circadian rhythms in response to blue or ultraviolet (UV-A) light. Cryptochromes, which evolved from DNA photolyases, may interact with magnetized water molecules, transferring magnetic energy to improve plant parameters. This hypothesis is supported by research showing that cryptochromes respond to magnetic fields and influence not only photosynthesis-related genes but also non-photosynthetic energy metabolism pathways like the Krebs cycle and oxidative phosphorylation.

Surendran *et al.* (2016) observed that magnetized water irrigation improved growth parameters in cowpea plants. Abedinpour and Rohani (2017) found that maize plants grown with saline water under magnetic technology exhibited enhanced growth compared to non-magnetized controls. Dawa *et al.* (2017) recorded the highest values for plant height, branch number, leaf number, leaf area, fresh and dry weights, and photosynthetic pigments in plants irrigated with magnetized water. Similarly, Doklega (2017) reported that potato plants irrigated with magnetized water showed significant improvements in growth and chlorophyll content. Olaniyi and Ogunlela (2017) demonstrated that magnetized water irrigation increased tomato plant height and yield, with faster growth rates compared to controls. Liu *et al.* (2017) found that magnetized water irrigation enhanced plant height, stem diameter, leaf area, root tip number, net photosynthetic rate, stomatal conductance, and water use efficiency (WUE), while reducing transpiration rates. Babaloo *et al.* (2018) revealed that magnetized water irrigation increased growth parameters, photosynthetic pigments, total carbohydrates, and total protein content in plants. Mahmoud *et al.* (2018) reported significant improvements in morpho-phenological parameters, including tree volume, fibrous root length, and leaf chlorophyll content, with magnetized water treatments. Additionally, Mahmoud *et al.* (2019) found that magnetized water irrigation, combined with nitrogen fertilization, increased leaf pigment content, dry matter, plant height, lateral shoot number, leaf area, and fibrous root growth. These studies collectively highlight the profound impact of magnetized water on plant growth, nutrient uptake, and overall crop productivity.

2-7- Magnetized water technology effect on yield.

Surendran *et al.* (2016) demonstrated that magnetized water irrigation significantly improved yield parameters in cowpea crops. Similarly, Doklega (2017) found that potato plants irrigated with magnetized water achieved the highest yield values compared to conventional irrigation methods. Nabile *et al.* (2017) also reported that magnetized water irrigation enhanced yields in apricot, peach, flame-seedless grape, and Thompson seedless grape, while simultaneously improving water productivity. Olaniyi and Ogunlela (2017) observed that magnetized water increased crop yields by 39% to 70% compared to untreated controls. Ageeb *et al.* (2018) showed that magnetic treatment boosted shoot growth and yield in tomato plants, resulting in a total yield of 50.52 tons per hectare, a 19.4% increase over the control yield of 42.32 tons per hectare.

Mahmoud *et al.* (2018) reported that magnetized water at 100% or 80% crop evapotranspiration (ETc) produced 2.54 kg and 2.57 kg of fruit per cubic meter of irrigation water in the first season, respectively. In the second season, magnetized water at 100% ETc yielded 3.22 kg of fruit per cubic meter, demonstrating the technique's ability to maximize water utilization and reduce irrigation requirements. Mahmoud *et al.* (2019) further revealed that combining magnetized water irrigation with nitrogen fertilization increased fruit set percentage, fruit quality, fruit weight, and overall tree yield.

3- Scientific explanations of magnetization effects.

It is a modern technology used by devices called magnetization devices. These devices produce a very intense concentration of the magnetic field through the wall of the tube to reach the water and contribute to the treatment. This magnetic field, which is very strong and intensely generated by the magnetization system, causes a change in the properties of the water. It affects the hydrogen bonds in the liquid water, which are highly affected by the magnetic field and the electrical, which changes the water properties, both physical and chemical.

When a substance passes through a magnetic pole, it cuts off the lines of the magnetic field and thus generates an electrical current (induced), that creates energy within the material. The magnetic field produces magnetic fluxes parallel to the water pipes that rearrange the direction of the ions and cations as shipped.

The magnetic field affects the angle of hydrogen-oxygen bonding in water molecules, which decreases from 107 to 103 degrees. These results in the formation of clusters of 6 to 7 molecules compared to 10-12 parts in normal state. Thus, small aggregates of water molecules formed by exposure to the magnetic field result in better absorption by the plant and faster penetration of the root hairs (Barefoot and Reich, 1992). It is easy to transfer magnetized water through the cellular membranes of the plant due to the formation of small groups of water, breaking the hydrogen bond, adjusting water properties and making it more soluble (reducing), which led to a decrease in viscosity and surface tension of water by 30 to 40% (Colic *et al.*, 1998).

Some photos showed effect of magnetic field on water characteristics according to Bondarenko *et al.*, 1999.

a **b**

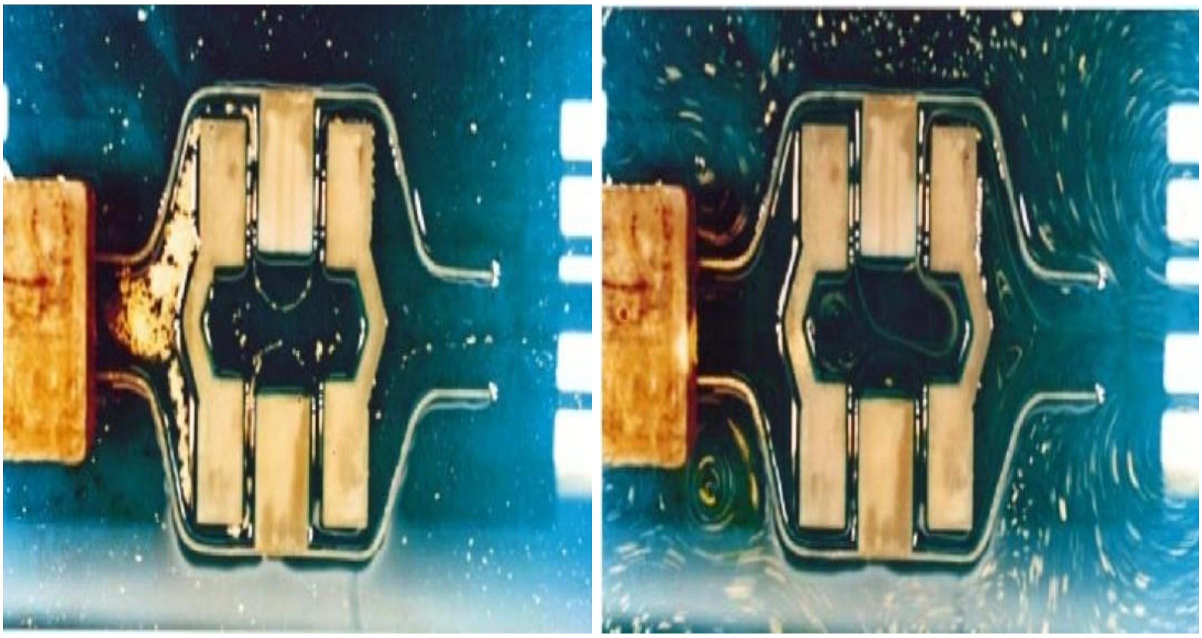

Fig. 1. Flow structure in the two-dimensional model of the magnetic apparatus at various values of current / in the inlet: (a) / = 0.1 A (laminar regime); (b) / = 1A (turbulent regime).

a **b**

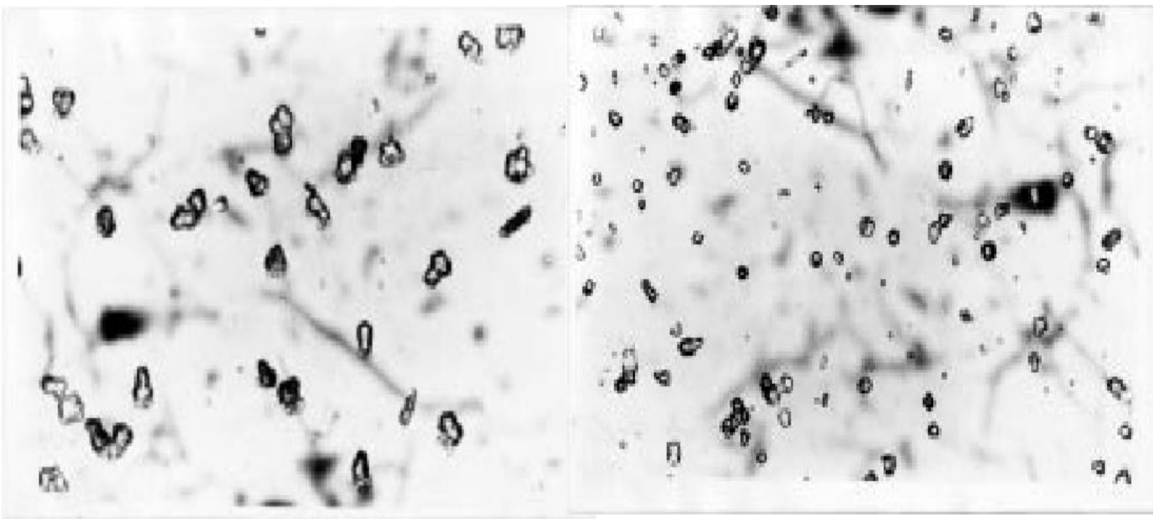

Fig. 2. Influence of magnetic treatment on crystallization of calcium carbonate in the calcite form. Solution: 10 mg equiv/L NaHCO3 10 mg equiv/L CaCl2. (a) Control solution; (b) solution after the treatment (flow rate of 0.2 L/s). Magnification is 400 X.

Table 1. Some physical and chemical characteristics for tap water before and after passing through the permanent magnets according to Ameen and Kassim, 2009.

Characteristics		Measurement units	Tap water		Change percentage (%)
			before magnetized	after magnetized	
Electroanalytical	PH	-	7.47	7.65	2.41
	EC	ds/m	0.758	0.759	0.13
	TDS	mg/l	453	395	12.80
	Water turbidity	NTU	610	498.5	12.28
	Water hard	mg/l	174.83	161.10	7.85
Physical	solubility	g/10ml	3.01	3.17	5.32
	Refractive index	-	1.3339	1.3340	0.007
	Density	g/ml	0.9979	0.9971	0.08
	Surface tension	din/cm	70.07	68.62	2.07
	Viscosity		0.714	0.698	2.24
	Evaporation	g/h	0.72	0.69	4.17
Dissolved ions	N	mg/l	3.5	3.5	-
	P	mg/l	0.2	0.2	-
	K^+	mg/l	1.71	1.67	2.34
	Ca^{++}	mg/l	69.93	69.93	-
	Mg^{++}	mg/l	29.7	29.11	1.99
	Na^+	mg/l	50.4	57.28	13.65
	$SO4^{--}$	mg/l	175.14	144.71	17.37
	$HCO3^-$	mg/l	101.79	92.33	9.29
	Cl^-	mg/l	102.59	86.15	16.02
	$BO3^-$	mg/l	-	-	-

Conclusion

Magnetized water is that passed through the magnetic field to induce some physical or chemical changes. When water passes through the magnetic field, it cuts off the lines of the magnetic field and thus generates an electrical current (induced) that is, it creates energy within the water. In addition, the magnetic field produces magnetic fluxes parallel to the water pipes that rearrange the direction of the ions and cations as shipped. The magnetic field also, affects the angle of hydrogen-oxygen bonding in water molecules, which decreases from 107 to 103 degrees and make water cluster formation contain 6 to 7 molecules compared to 10-12 parts in normal state. The above effect decreases of both surface tension and viscosity by 30 to 40% in water and this led to better water absorption by the plant and faster penetration of the root hairs. It also, transfer magnetized water through the cellular membranes easily. Magnetic field causes an increase in the kinetics of salts atoms, thus breaking the hydrogen bond, adjusting water properties and making it more soluble. This change in the properties of water has a positive effect on phyto-hormone production, mobile forms of fertilizers, water absorption, moisture content, photosynthetic pigments, endogenous promoters (IAA) and bio-enzyme systems, while lowering soil alkalinity and dissolving soluble salts (carbonates, phosphates and sulfates) leading to improved cell activity, plant growth and crop yield.

Consent for publication:

The author declares their consent for publication.

Author contribution:

The manuscript was edited and revised by the author.

Conflicts of Interest:

The author declares no conflict of interest.

References

Abd El-All, H., Ali, S.M. and Shahin S. (2013) Improvement growth, yield and quality of squash (*Cucurbita pepo* L.) plant under salinity conditions by magnetized water, amino acids and selenium. *Journal of Applied Sciences Research*, 9 (1): 937-944.

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

Addad, D., Hamli, S., Mekersi, N., Kadi, K., Dib, D., Hamdellou, A., Khelifi, A., Lekmine, S., Kellil, H., Gueboudji, Z. and Bouzerzour, H. (2025). Morpho-physiological responses of durum wheat (*Triticum durum* Desf.) seedlings to drought stress and their correlation with yield. *Egyptian Journal of Agronomy*, 47 (2): 197-209.

Ageeb, G.W., Talaab, A.S. and Abd El-Hady, M. (2018) The impact of magnetized saline irrigation water treatment on soil, water and plant. *Bioscience Research*, 15(4): 4106-4112.

Ali, T.B., Khalil, S.E. and Khalil, A.M. (2011) Magnetic treatments of *Capsicum Annuum* L. grown under saline irrigation conditions. *Journal of Applied Sciences Research*, 7(11): 1558-1568.

Alikamanoglu, S. and Sen, A. (2011) Stimulation of growth and some biochemical parameters by magnetic field in wheat (*Triticum sativum* L.) tissue cultures. *African Journal of Biotechnology*, 10: 10957-10963.

Aly, M.A., Thanaa, M.E.; Osman, S.M. and Abdelhamed, A.A.M. (2015) Effect of magnetic irrigation water and some anti-salinity substances on the growth and production of Valencia orange. *Middle East Journal of Agriculture Research*, 4: 88-98.

Alzubaidi, S.A. (2018) Effect of magnetized water on the germination of Cotton seeds (*Gossypium hirsutum* L.) under different conditions of saline stress. *Kufa Journal for Agricultural Science*, 10(4): 74-86.

Ameen, S.K.M. and Kassim, A.F. (2009) Influence of magnetized saline irrigating water on vegetative growth of *Gerbera jamesonii*. *Damascus University Journal for the Agricultural Sciences*, 25(1): 63-74.

Amer, M.M., El-Sanat, A.G. and Rashed, S.H. (2014) Effects of magnetized low quality irrigation water on some soil properties and soybean yield (*Glycine max* L.) under salt affected soils conditions. *Journal of Soil Sciences and Agricultural Engineering, Mansoura University*, 5(10): 1377-1388.

Babaloo, F., Majd, A., Arbabian, S., Sharifnia, F. and Ghanati, F. (2018) The Effect of Magnetized Water on Some Characteristics of Growth and Chemical Constituent in Rice (*Oryza sativa* L.) Var Hashemi. *EurAsian Journal of Biosciences*, 12(1): 129-137.

Barefoot, R.R. and Reich, C.S. (1992) The calcium factor: The scientific secret of health and youth. South eastern, PA: Triad Marketing, 5th edition.

Bondarenko, N.P.H., Gak, E.Z., Rokhinson, E.E. and Ananyev, I.P. (1999) Magnetic treatment of irrigation water: experimental results and application conditions. *Environmental Science Technology*, 33: 1280-1285.

Colic, M., Chien, A. and Morse, D. (1998) Synergistic application of chemical and electromagnetic water treatment in corrosion and scale prevention. *Croatica Chemica Acta*, 71(4): 905-916.

Dawa, K.K. Abd El-Nabi, H.M.E. and Swelam, W.M.E. (2017) Response of tomato plants to irrigation with magnetized water and some foliar application treatments under drip irrigation system: 1- vegetative growth and chemical constituents of leaves. *Journal of Plant Production*, 8(11): 1127-1133.

Doklega, Samar M.A. (2017) Impact of magnetized water irrigation, soil mineral fertilization and foliar spraying with nanomaterial on potato plants. *Journal of Plant Production*, 8(11): 1113-1120.

Esmaeilnezhad, E., Choi, H. J., Schaffie, M., Gholizadeh, M. and Ranjbar, M. (2017) Characteristics and applications of magnetized water as a green technology. *Journal of Cleaner Production*, 161: 908-921.

Ha, D.W., Kwon, J.M., Baik, S.K., Lee, Y.J., Han, K.S., Ko, R.K., Sohn, M.H. and Seong, K.C. (2011) Purification of condenser water in thermal power station by superconducting magnetic separation. *Physica C: Superconductivity and its Applications*, 471: 1530-1532.

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

Hozayn, M., Qados, A. and Saeed, A.M. (2010) Magnetic water application for improving wheat (*Triticum aestivum* L.) crop production. *Agriculture & Biology Journal of North America*, 1(4): 677-682.

Liu, X., Ma, F., Zhu, H., Ma, X., Guo, J., Wan X., Wang, L., Wang, H. and Wang, Y. (2017) Effects of magnetized water treatment on growth characteristics and ion absorption, transportation, and distribution in *Populus × euramericana* 'Neva' under NaCl stress. *Canadian Journal of Forest Research*, 47(6): 828-838.

Maffei, M.E. (2014) Magnetic field effects on plant growth, development, and evolution. *Plant Science*, 4(5): 445-460.

Mahmood, S. and Usman, M. (2014) Consequences of Magnetized Water Application on Maize Seed Emergence in Sand Culture. *Journal of Agricultural Science and Technology*, 16(1): 47-55.

Mahmoud, T.A., Youssef, Ebtessam A., El-harouny, S.B. and Abo Eid, Manal A.M. (2018) Effect of magnetized water and different levels of water supply on growth and yield of navel orange trees. *Journal of Horticultural Science and Ornamental Plants*, 10(3): 118-128.

Mahmoud, T.A., Youssef, Ebtessam A., El-harouny, S.B. and Abo Eid, Manal A.M. (2019) Study of the effect of salinity stress and magnetized water irrigation on growth of Washington navel orange seedlings budded on sour orange rootstock. *Plant Archives*, 19(1): 711-720.

Mahmoud, T.A., Youssef, Ebtessam A., El-harouny, S.B. and Abo Eid, Manal A.M. (2019) Effect of irrigation with magnetic water on nitrogen fertilization efficiency of navel orange trees. *Plant Archives*, 19(1): 966-975.

Mostafa, M.F.M. El-Boray, M.S.S., Shalan, A.M.N. and Ghaffar, A.H. (2016). Effect of magnetized irrigation water levels and compost on vegetative growth, leaf mineral content and water use efficiency of Washington navel orange trees. *Journal Plant Production, Mansoura University*, 7(2): 249-255.

Mostafazadeh-Fard, B., Khoshravesh, M., Mousavi, S.F. and Kiani, A.R. (2011) Effects of magnetized water and irrigation water salinity on soil moisture distribution in trickle irrigation. *Journal of Irrigation and Drainage Engineering*, 137(6): 398-403.

Nabile E.F., Mohamed, Amira A. and Shaban, K.A. (2017) Effect of Magnetic Treatment of Irrigation Ground water on Soil salinity, Nutrients, Water Productivity and Yield Fruit Trees at Sandy Soil, 10(57): 113-123.

Olaniyi, Y.K. and Ogunlela, A.O. (2017). Effects of magnetized water on the vegetative growth and yield of tomato. *Agricultural Engineering International: CIGR Journal*, 19(1): 1-8.

Radhakrishnan, R and Kumari, B.D.R. (2012). Pulsed magnetic field: A contemporary approach offers to enhance plant growth and yield of soybean. *Plant Physiology and Biochemistry*, 51: 139-144.

Rajan, R., Kumar, D.J.M., Perumal, P. and Kumar, A. (2017). Effect of bio-availability of magnetized water on different biological systems. *Journal of Pure and Applied Microbiology*, 11(2): 1183-1188.

Rashidi, S.; Yadollahpour, Shirali, S. and Rajashekar, G. (2016). Magnetized water treatment: reviewing the environmental applications. *International Journal of Pharmacy & Technology*, 8(1): 11431-11441.

Surendran, U., Sandeep, O. and Joseph, E.J. (2016). The impacts of magnetic treatment of irrigation water on plant, water and soil characteristics. *Agricultural Water Management*, 178: 9-21.

Yamamoto, J., Mori, T., Akiyama, Y., Okada, H., Hirota, N., Matsuura, H., Namba, S., Sekine, T., Mishima, F. and Nishijima, S. (2019). Removal of Iron Scale from Boiler Feed-Water in Thermal Power Plant by Magnetic Separation: Large-Scale Experiment. *Journal of Transactions on Applied Superconductivity*, 29(5): 60-70.

Younis, A.M., Mansour, H.A. and Bakry, A. B. (2025). Enhancing maize productivity through aquacrop modeling under modern irrigation systems and drought stress conditions. *Egyptian Journal of Agronomy*, 47 (1): 55-71.

Youssef, Ebtessam A., Abdelbaset, Marwa M. and El-Shafie, A. F. (2025). Impact of licorice extract foliar application on some growth and yield parameters on wheat grown under water stress conditions. *Egyptian Journal of Agronomy*, 47 (1): 133-143.

Youssef, Ebtessam A., Abdelbaset, Marwa M. and El-Shafie, A. F. (2025). Citric acid foliar application impact on growth and yield parameters of maize (*zea mays*) under drought stress conditions. *Egyptian Journal of Agronomy*, 47 (1): 145-155.

Youssef, Ebtessam A. and Taha, Sahar S. (2016). Effect of moisture stress and magnetized water on growth parameters and yield characteristics of onion plants. *International Journal of PharmTech Research*, 9(9): 104-111.