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EFFECT OF MAGNETIZED WATER AND SEAWEED EXTRACT ON GROWTH AND YIELD OF SQUASH (*CUCURBITA PEPO* L.) PLANTS GROWN UNDER SALINE CONDITIONS

Mansour El-Sayed Ramadan* **and Osama Abdelsalam Shalaby**
Department of Plant Production, Desert Research Center, Egypt
*E-mail: ramadandrc79@gmail.com

Salinity is one of the most important environmental stresses affecting agricultural productivity globally. Magnetic field and seaweed extract are effective and emerging tools to increase tolerance against adverse environments leading to maximizing yields. The current study aimed to clarify the effect of magnetized irrigation water and seaweed extract on growth, yield and the changes in chlorophyll content and mineral composition of squash (*Cucurbita pepo* L.) cv. El-Eskandarani. This experiment was carried out in the summer 2022 and 2023 seasons at the Experimental Station of Desert Research Center in Ras Sudr, South Sinai Governorate, Egypt. In this experiment, the plants were treated with the magnetic field (untreated water and magnetized water) and different foliar applications of seaweed extract (0, 0.5, and 1 g L^{-1}). The results showed that growth parameters, chlorophyll content, NPK content of leaves, yield and its components were increased with irrigation using magnetized water and foliar application of seaweed extract, while the content of Na and Na^+/K^+ ratio were decreased using magnetized water and foliar application of seaweed extract. The best results in terms of growth, chlorophyll content, mineral content, yield and its components were observed in plants irrigated with magnetized water and sprayed with seaweed extract at 1 g L^{-1}. In conclusion, magnetic treatment of saline water and seaweed extract spraying improved growth and yield of squash plants under saline conditions.

Keywords: salinity, magnetic field, seaweed extract, *Cucurbita pepo*, yield

INTRODUCTION

Squash (*Cucurbita pepo* L.) is one of the most important crops of vegetables in the Cucurbitaceae family and is a popular widely used crop worldwide. It is grown for its fruit, which has several precious nutritional components for human dietary needs (Paksoy and Aydin, 2004 and Bello et

al., 2022). Squash is a moderately sensitive or moderately tolerant crop for abiotic stress conditions including salinity (Francois, 1985 and Huang et al., 1995). According to the Ministry of Agriculture statistics in Egypt, the total cultivated area in 2019 was 49704 feds, producing about 388834 tons and an average of 7.823 tons/fed.

Salinity is one of the most important environmental factors that seriously jeopardize the ability of most crops to survive, grow, and produce (Kulak et al., 2020). It is a devastating factor imposing plant growth and shifting the metabolism of the plants (Hu et al., 2012 and Ikbal et al., 2014). To mitigate this issue on crop production, some technologies were investigated such as magnetized water. Magnetized water is one of the promising methods that have been used in saline water management for irrigation. The physical properties of water, such as density, dissolved salt capacity, and solid particle sedimentation ratio, are changed by magnetized water, enhancing soil fertility and promoting plant growth (Liu et al., 2019 and Hozayn et al., 2022). Magnetized water can be applied as a successful and sustainable way to preserve plant yield in a variety of abiotic stress situations (Wang et al., 2018). It could alleviate the salinity disorders of plants by improving antioxidant capacity and enhancing plant growth and biomass, especially in severe saline conditions (Khosrojerdi et al., 2023). Also, magnetic irrigation water improves nutrient uptake and water use efficiency in plants; it could be explained by the reorientation of membrane phospholipids increasing membrane permeability. This changes the sodium and calcium channels in the membrane, allowing ions to enter the cell. (Rosen, 2003). Previous research has shown that magnetic saline water enhances plant growth features and boosts plant production (El-Zawily et al., 2019; Samarah et al., 2021; Hozayn et al., 2022 and Kishore et al., 2023).

Mostly made up of natural hormones including auxin, cytokinin, gibberellin, and abscisic acid, seaweed extracts (SWE) are a type of biostimulant derived from seaweed that also contains other active ingredients such sugar alcohol, betaine, seaweed polysaccharide, and phenolic compounds (Battacharyya et al., 2015). The growth-promoting and stress-resistant properties of SWE make them popular biostimulants in crop management under salinity stress (Chen et al., 2021 and Hassan et al., 2021). Plants treated with SWE have higher leaf gas exchange rate, chlorophyll index, and improved leaf nutritional status, as evidenced by higher K and lower Na concentrations. This allows assimilates to be translocated more efficiently to photosynthetic sinks regardless of the treatment for salt stress, improving crop performance (Rouphael et al., 2017 and Jafarlou et al., 2023). Furthermore, other studies showed that the application of SWE promotes plant growth and photosynthetic (Chen et al., 2021), leaf nutrient contents (Ahmed and Shalaby, 2012 and Rouphael et al., 2017), and enhanced plant yield (Rouphael et al., 2018; Rasheed and Shareef, 2019 and Ashmawi et al., 2021). Therefore, in this work, the effects of magnetic saline

water and SWE on plant growth and yield of squash plants under saline conditions were studied.

MATERIALS AND METHODS

1. Plant Materials and Experimental Treatments

In this study, the experiment was conducted in an open field at the Experimental Ras Sudr Station, Desert Research Center, Egypt during the summer 2022 and 2023 seasons, to study the effects of magnetized water and SWE on the growth and yield of squash (*Cucurbita pepo* L.) plants grown under salinity conditions (salinity of experimental soil and irrigation water were about 7556 and 6321 ppm, respectively). The soil at the experimental location was sand in texture (according to international textural grade), and made up of 89.12% sand, 6.34% silt, and 4.54% clay. The water and soil were analyzed and presented in Table (1) according to the methods described by Burt (2004).

Table (1). Water and soil chemical analysis.

	pH	EC (ppm)	Cations (meq L^{-1})				Anions (meq L^{-1})			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Water	8.52	7556	20.11	14.66	128.32	2.31	-	7.50	105.1	41.6
Soil	8.72	6321	5.80	4.50	96.35	1.56	-	5.63	67.5	28.4

This experiment included six treatments which were the combinations of two magnetic water treatments (untreated water and magnetically-treated water) and three foliar applications of SWE levels (0, 0.5, and 1 $g \cdot L^{-1}$). The experimental treatments were implemented in a split-plot design with three replications, the magnetic water treatments were randomly arranged in the main plots and SWE levels were randomly arranged in the subplots. To treat water with a stationary magnetic field, magnetic treatment was carried out using a magnetic apparatus exactly as described by Shalaby (2008). A plastic tube of 16 ml in diameter and 60 cm in length, commonly employed in plant irrigation lines, was utilized to create the gadget that magnetized irrigation water in the field. According to the specifications of the magnet units, ten identical permanent magnet units were positioned in a unipolar configuration (facing the magnetic poles) with a spacing of 8 cm between each magnet and an intensity of 800 Gauss. These devices were put in the foreword of the irrigation lines in field treatments where water that had been magnetically treated was used for irrigation. Seaweed extract (SWE) foliar application was performed using commercial product Oligo-X which was purchased from Agricultural Development Union Company, Egypt. It combines three types of seaweed: *Ascophyllum nodosum*, *Laminaria* spp., and *Sargassum* sp. In addition, it has oligosaccharides (3%), algnic acid (5%), phytin (0.003%), menthol (0.001%), pepsin (0.02%), and minerals (potassium oxide 12%, phosphorus

oxide 0.5%, N1%, Zn 0.3%, Fe 0.2%, and Mn 0.1%). Foliar spraying with SWE was initiated 15 days after sowing and continued thrice every 10 days during the growth season.

Squash seeds of the El-Eskandarani variety were obtained from Agricultural Research Center, Egypt. The seeds were sown in rows of 4 m in length, 1 m in breadth, and 50 cm between plants on the 1st of April of both the summer seasons (2022 and 2023). The experimental plot had five rows and a 20 m^2 area. Every three days, plants were irrigated with saline water. The Egyptian Ministry of Agriculture's recommendations for growing squash in recently recovered sandy soil areas were followed in all agricultural practices.

2. Plant Growth Measurements

To measure the following squash plant growth parameters, a random sample of five plants was harvested from each plot 50 days after sowing in both seasons: plant height, number of leaves per plant, leaf area per plant, fresh and dry biomass yield per plant. Leaf area estimation was determined at harvest using the leaf disk method (Hafez et al., 2018). Ten leaf disks were taken per plant with the aid of a cylindrical soil core (19.625 cm^2). After determining the fresh and dry weight of the ten leaf disks, the following equation was used to determine the total leaf area per plant:

$$Leaf\ area = \frac{\text{weight of total leaves (g/plant)} \times 10\ \text{n}}{\text{Weight of 10 leaf disks (g/plant)}}$$

Where n = area of one disk

3. Determination of Chlorophyll and Carotenoids

Chlorophyll a, chlorophyll b, and carotenoids were measured using UV-VIS spectroscopy. In a test tube, 0.05 g of leaf tissue was suspended in 5 mL of 95% ethyl alcohol at 60 C until the suspension became colorless. Next, 95% ethyl alcohol was added to refill the entire capacity to 5 mL. The green solution was put in a cuvette with a blank of one milliliter of 95% ethyl alcohol. At wavelengths of 664, 649, and 470 nm, spectrophotometry was used to detect the absorbance readings using a Lamda 25 UV-Vis spectrophotometer (Su et al., 2010).

4. Determination of N, P, K and Na Content

Mature, fully expanded, healthy leaf blades were sampled from plants in each plot 45 days after planting. The blades were taken out of the petiole of the leaf, cleaned, dried at 70°C, and then finely powdered in a blender. nitrogen was determined by the Kjeldahl method (Jackson, 1973), Using molybdovanadate-yellow colorimetry, nitrate-perchloric acid digests of the ground blades were examined for P content (Kitson and Mellon, 1944), K and Na by the use of flame photometric method (Chapman and Pratt, 1982). Finally calculate the Na/K ratio according to the ion concentrations.

5. Yield and Its Components

Fruit harvested 2-3 times a week when it reached a marketable stage. Number of fruits per plant, fruit weight, yield per plant and total yield (ton/fed) were determined.

Feddan = 4200 m^2 = 0.42 hectare

6. Statistical Analysis

The experimental treatments were implemented factorial, based on split plot design with three replications. Data were analyzed with CoStat statistical software to determine significant differences between treatments. Mean comparisons were performed with Duncan's multiple range test at the 5% level of significance (Duncan, 1958).

RESULTS AND DISCUSSION

1. Plant Growth Characteristics

The data in Table (2) demonstrate that the various combinations of magnetized irrigation water and SWE treatments significantly affected the plant growth characteristics. The highest values of plant height, number of leaves per plant, leaf area per plant, fresh biomass yield per plant, and dry biomass yield per plant were in magnetically treated water compared with untreated water (control) in both seasons. These results concurred with previous studies on several crops, such lettuce (Putti et al., 2023), tomato (Dawa et al., 2017; El-Zawily et al., 2019 and Samarah et al., 2021) and chickpea (Hozayn et al., 2022), showing an increase in growth characteristics of plants irrigated with magnetized water. The increase in plant growth following magnetic field treatment could be attributed to improved enzymes activation and increased levels of endogenous hormones during the growth period. This could have improved the absorption and transportation of mineral nutrients, even in salinity-prone environments (Surendran et al., 2013). Additionally, the application of magnetic treatment increased the population of soil microbes, which may raise the bioavailability of macro/microelements in the soil for quick plant uptake. This could lead to improved root development, increased uptake of water and minerals, and the production of plant hormones that could be responsible for improved plant growth (Ratushnyak et al., 2008 and Dawa et al., 2017). Hilal et al. (2002) also observed that the use of magnetized water causes a decrease in soil alkalinity, an increase in the leaching of excess soluble salts, and the dissolution of slightly soluble salts like phosphates, carbonates, and sulfates. These actions reduce saline stress on plants and improve nutrient absorption, which in turn promotes plant growth.

Table (2). Effect of magnetized irrigation water and seaweed extract on plant growth characteristic of squash plants at 50 days after sowing in 2022 and 2023 seasons.

Magnetic treatment	Seaweed extract (g L^{-1})	Plant height (cm)		Number of leaves/plant		Leaf area (m^2/plant)		Fresh biomass yield (g/plant)		Dry biomass yield (g/plant)	
		2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
UW		31.35b	37.28b	12.47b	11.85b	0.579b	0.751b	971.99b	1021.13b	159.63b	158.13b
MTW		36.52a	40.54a	15.00a	14.21a	0.761a	0.968a	1060.08a	1219.05a	173.91a	189.10a
	0	30.70c	34.99c	12.01c	11.76c	0.461c	0.666c	751.76c	976.06c	124.34c	148.83b
	0.5	33.21b	38.28b	13.52b	12.74b	0.731b	0.990a	1121.09b	1207.81a	180.58b	184.98a
	1.0	37.91a	43.47a	15.67a	14.59a	0.819a	0.923b	1175.26a	1176.39b	195.40a	187.04a
	0	30.19e	34.24c	11.14d	10.86d	0.412e	0.616e	730.90c	817.60d	122.02c	124.44d
UW	0.5	29.41e	36.04c	12.16c	11.55d	0.675c	0.782d	1032.05b	1119.69c	165.66b	171.21c
	1.0	34.46c	41.57b	14.10b	13.13c	0.650c	0.856c	1153.01a	1126.10c	191.21a	178.75b
	0	31.20d	35.74c	12.87c	12.65c	0.509d	0.716d	772.61c	1134.52c	126.66c	173.21c
MTW	0.5	37.01b	40.52b	14.88b	13.93b	0.786b	1.198a	1210.13a	1295.94a	195.50a	198.76a
	1.0	41.36a	45.36a	17.24a	16.04a	0.987a	0.991b	1197.50a	1226.68b	199.58a	195.33a

UW: Untreated water; MTW: Magnetically-treated water

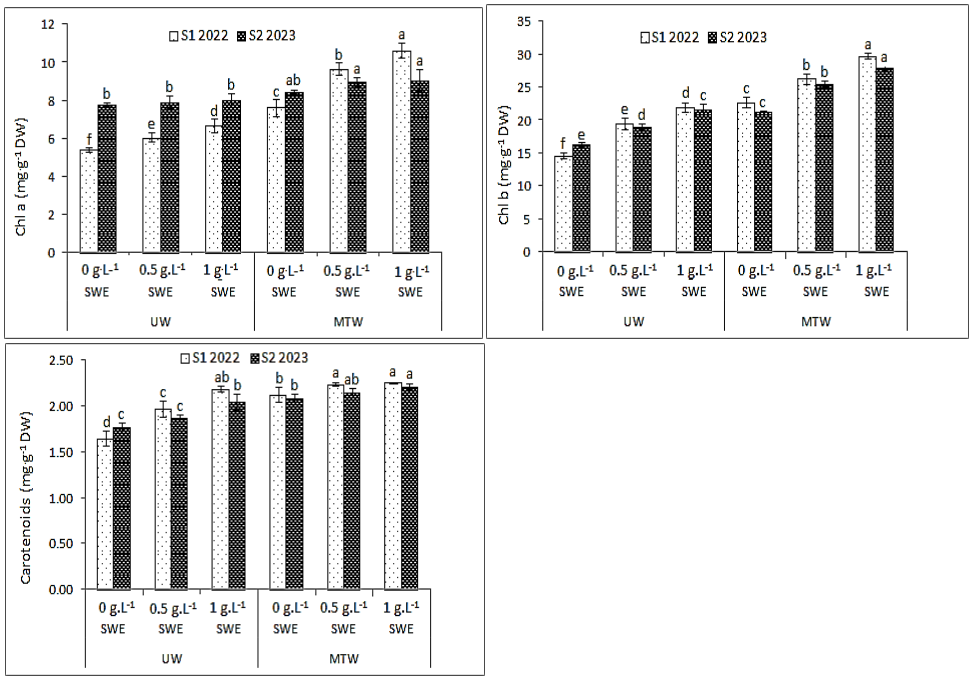
The values of growth characteristics of plants (plant height, number of leaves per plant, leaf area per plant, fresh biomass yield per plant, and dry biomass yield per plant) increased significantly after SWE spraying in both growing seasons (Table 2). The higher values were observed in SWE-treated plants at 1 g L^{-1} compared to control in both seasons, except the highest values of leaf area and fresh biomass yield per plant in the second season were observed in SWE-treated plants at 0.5 g L^{-1}. These results are in harmony with the findings of Ashmawi et al. (2021) and Jafarlou et al. (2023), who found that applying of the SWE increased in plant growth parameters under saline irrigation water conditions. The application of SWE may have satisfactorily stimulated plant development by mitigating the adverse effects of salinity on plants, as well as by increasing the activity of antioxidant enzymes and gas exchanges, which in turn reduced oxidative damage under salinity stress conditions (Jafarlou et al., 2023). Additionally, because SWE contains macro and microelements, it may improve some plants' growth ability (Zewail, 2014; Raghunandan et al. 2019; Carillo et al. 2020 and Jafarlou et al., 2023). Furthermore, the results of other research indicated that compounds that improve growth, like the composition of amino acids, betaines, auxins, cytokinins, gibberellins, and abscisic acid, might have appeared in seaweed (Blunden and Gordon, 1986 and Battacharyya et al. 2015). At the magnetized irrigation water, foliar spraying with SWE at level 0.5 or 1 g L^{-1} treatments gave the maximum values of plant growth characteristics in both seasons. The minimum plant growth characteristics values were obtained with untreated irrigation water without SWE application in both seasons.

2. Chlorophyll and Carotenoids

Data illustrated in Fig. (1) show that using magnetized water as a source for irrigating squash significantly increased chlorophyll a, b, and carotenoids content compared with untreated irrigation water in both seasons. The findings were consistent with previously published research on rosemary (El-Kholy et al., 2020), chickpea (Hozayn et al., 2022), tomato (Firrer-Dubois et al., 2022) and sugar beet (Enan et al., 2023). The positive effects of magnetic water on photosynthetic pigments could potentially stem from the paramagnetic characteristics of chloroplasts, which are influenced by magnetic treatment. This leads to an increase in ion mobility and absorption, which in turn promotes photostimulation and growth (Sutiyanti and Rachmawati, 2021). Furthermore, magnetized water raises the levels of chlorophyll and carotenoids in leaves; this may be due to proline and GA_3, which are brought on by the buildup of Mg^{2+} for the synthesis of chlorophyll (Radhakrishnan 2019) and K^+ to increase the number of chloroplasts (Reina and Pascual, 2001).

Fig. (1) shows the impact of different doses of SWE on chlorophyll a, b, and carotenoids content of squash plants during two growing seasons,

2022 and 2023. The results showed that the application of 1 g L^{-1} SWE had a significant impact on the levels of chlorophyll a, b, and carotenoids; these levels reached 8.61, 25.75, and 2.22 mg g^{-1} DW, respectively, in the first season, and 8.51, 24.66, and 2.13 mg g^{-1} DW, respectively, in the second season. In contrast, in the absence of SWE treatment (control), the levels of chlorophyll a, b, and carotenoids dropped to as low as 6.49, 18.58, and 1.88 mg g^{-1} DW, respectively, in the first season, and 8.10, 18.75, and 1.92 mg.g^{-1} DW, respectively in the second season. These findings are in line with those of Rouphael et al. (2017), Ashmawi et al. (2021), Chen et al. (2021) and Jafarlou et al. (2023).



UW: Untreated water; MTW: Magnetically-treated water; SWE: Seaweed Extract

Fig. (1). Effect of magnetized irrigation water and seaweed extract on chlorophyll a, b and carotenoids content of squash plants at 50 days after sowing in 2022 and 2023 seasons.

The increase of chlorophyll content observed may be a result of the effects of SWE by increasing the biogenesis of chloroplasts and decreasing chlorophyll degradation, which was due to the up-regulated genes linked to photosynthesis, cell metabolism, stress response, and S and N metabolism in plants (Jannin et al., 2013). Moreover, included in SWE is magnesium, which is essential for chlorophyll synthesis (Almaroai and Eissa, 2020). Using magnetized water to irrigate plants sprayed with a concentration of 1 g

L^{-1} SWE had the best results in terms of the content of chlorophyll a, b, and carotenoids; untreated water and plants not sprayed with SWE produced the opposite outcomes.

3. Mineral Content of Leaves

The effects of magnetized irrigation water and different SWE levels on the N, P, K, Na content, and Na^+/K^+ ratio in leaves during the 2022 and 2023 growth seasons are shown in Table 3. When plants were irrigated with magnetically-treated water as opposed to untreated water, the content of N, P, and K was significantly higher in the treated plants, whereas the content of Na and the ratio of Na^+/K^+ were lower in the treated plants in both seasons. These findings could be explained by how water exposed to a magnetic field affected the pH of the soil, which could encourage plants to better absorb nutrients (Maheshwari and Grewal, 2009 and Hozayn et al., 2017), also promotes the growth of plants roots systems (Garnett et al., 2009), thereby increasing the nutrients absorption by plants under stressful conditions (Abobatta, 2019; Selim et al, 2019 and Meng et al., 2019). Similar results were reported to tomato (El-Zawily et al., 2019), fennel (Faridvand et al., 2021), chickpea (Hozayn et al., 2022) and lettuce (Putti et al., 2023).

Seaweed extracts (SWE) had a significant effect on content of N, P, K and Na, and Na^+/K^+ ratio in leaves (Table 3). The findings showed that, in comparison to plants not sprayed with SWE, SWE spraying enhanced the content of N, P, and K in plant leaves, while dramatically lowering the content of Na and the Na^+/K^+ ratio in plant leaves during both seasons. The application of SWE can encourage crop root growth and enhance the capacity of roots to absorb element nutrients and transmit them to the aboveground, which could have an impact on the N, P, and K levels (Crouch et al., 1990), which is associated to the hormones substances in SE (Finnie and van Staden, 1985 and Jeannin et al., 1991), and the hormones substances may encourage up-regulated nutrient transport genes expression, thus enhancing nutrient absorption and transport by the roots (Krouk et al., 2010 and Rathore et al., 2009). The application of SWE may have enhanced the biomass, which is why the Na content decreased (Rouphael et al., 2017). The findings are consistent with those reported by Shehata et al. (2011), Rouphael et al. (2017), Chen et al. (2021) and Jafarlou et al. (2023). Plants irrigated with magnetically treated water sprayed with 1 g L^{-1} SWE had the highest concentrations of N, P, and K and the lowest contents of Na and the Na^+/K^+ ratio in both seasons.

Table (3). Effect of magnetized irrigation water and seaweed extract on leaf mineral content of squash plants at 50 days after sowing in 2022 and 2023 seasons.

Magnetic treatment	Seaweed extract (g L^{-1})	N (mg/g DW)		P (mg/g DW)		K (mg/g DW)		Na (mg/g DW)		Na^+/K^+ Ratio	
		2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
UW		21.89b	22.88b	2.80b	2.68b	20.88b	19.23b	2.90a	2.66a	0.140a	0.141a
MTW		23.77a	24.46a	3.11a	3.01a	25.49a	23.66a	2.09b	1.92b	0.083b	0.082b
	0.0	21.94b	22.87b	2.83c	2.67c	21.88c	19.72c	2.66a	2.51a	0.125a	0.133a
	0.5	23.04a	24.01a	2.95b	2.86b	23.13b	21.54b	2.49b	2.28b	0.111b	0.109b
	1.0	23.50a	24.14a	3.09a	3.01a	24.56a	23.08a	2.34b	2.08c	0.098c	0.092c
UW	0.0	20.85c	22.13d	2.65d	2.55e	19.72c	17.00d	2.98a	2.84a	0.152a	0.169a
	0.5	22.21b	22.88c	2.77c	2.68d	20.34c	19.39c	2.87a	2.65b	0.142a	0.137b
	1.0	22.61b	23.62b	2.98b	2.82c	22.58b	21.31bc	2.86a	2.49b	0.127b	0.117c
MTW	0.0	23.04b	23.60b	3.01b	2.79c	24.03b	22.44ab	2.34b	2.17c	0.097c	0.097d
	0.5	23.88a	25.13a	3.13a	3.04b	25.92a	23.69ab	2.11c	1.90d	0.082d	0.080de
	1.0	24.39a	24.65a	3.20a	3.19a	26.53a	24.85a	1.82d	1.68e	0.069d	0.068e

UW: Untreated water; MTW: Magnetically-treated water

4. Yield and Its Components

Table (4) shows the influence of magnetized irrigation water and different doses of SWE on the yield and its components during the two seasons, 2022 and 2023. It was noted that, in comparison to untreated irrigation water, the treatment with magnetized irrigation water had a significantly affected on the number of fruits per plant, fruit weight, yield per plant, and total yield in both seasons. Plants irrigated with magnetized water had the highest values for number of fruits per plant, fruit weight, yield per plant, and total yield; plants irrigated with untreated water had the lowest values in both seasons. These results concurred with previous studies on several crops such as tomato (Samarah et al., 2021), groundnut (Hozayn et al, 2017), lettuce (Putti et al., 2023) and French bean (Kishore et al., 2023). The increment in yield and its components as a result of magnetic field treatment may be attributed to increased ability to absorb nutrients and water, as well as greater shoot and root growth (De Souza et al., 2005). Also plants under a magnetic field have less oxidative stress and an increase in antioxidants, which mitigates the consequences of stress (Radhakrishnan, 2019), which led to an increase in growth and, as a result, yield and its components (El-Zawily et al., 2019). In addition, the increase in yield and its characteristics might be attributed to the stimulatory role of magnetic treatment in growth parameters, photosynthetic pigment contents, osmoprotectants, and total IAA contents in plants (Hozayn et al., 2022).

The SWE foliar application enhanced the yield and components of squash as compared to the control treatment in both seasons. Data in Table (4) show that spraying SWE at 1 g L^{-1} resulted in higher significant values of the number of fruits per plant, fruit weight, yield per plant, and total yield in both seasons. The control plants had the lowest yield and yield components in both seasons. These findings are consistent with those mentioned for squash (Rouphael et al., 2017), cucumber (Ahmed and Shalaby, 2012), Hassan et al., 2021), strawberry (Alkharpotly et al, 2017), eggplant (Rasheed and Shareef, 2019) and tomato (Ashmawi et al., 2021). It is possible that stimulating influence of SWE on yield and its components results from enhanced chemical and physical characteristics related to stress defense, immunity, and production (Hassan et al., 2021), Also, it is believed that the yield increases are thought to be related to the hormonal content, and particularly cytokinin content, of the SWE (Brain et al., 1973), where cytokinins in vegetative plant parts are related to the distribution of nutrients, but a significant fraction of cytokinins in reproductive organs may be associated to the mobilization of nutrients (Abd El-Gawad and Osman, 2014). On the other hand, the role that SWE plays in promoting growth which raises the number of flowering clusters may also be responsible for the increase in yield. This is because the extract improves physiological processes including photosynthesis and plant nutrient absorption (Al-Saaberi, 2005). Regarding the interaction between magnetized irrigation

water and SWE, plants irrigated with magnetized water and foliar application of SWE at 1 g L^{-1} produced the highest number of fruits per plant, fruit weight, yield per plant, and total yield, while the lowest values were obtained from plants irrigated with untreated water in the absence of SWE foliar application in both seasons.

Table (4). Effect of magnetized irrigation water and seaweed extract on yield and its components of squash plants at harvest in 2022 and 2023 seasons.

Magnetic treatment	Seaweed extract (g L^{-1})	Number of fruits/plant		Fruit weight (g)		Yield/plant (g)		Total yield (ton/fed)	
		2022	2023	2022	2023	2022	2023	2022	2023
UW		4.99b	5.20b	70.83b	77.35b	354.17b	403.08b	2.98b	3.39b
MTW		5.73a	5.91a	90.88a	93.59a	524.26a	556.28a	4.40a	4.67a
	0.0	5.01c	5.19c	72.54c	77.47c	364.96c	402.73c	3.07c	3.38c
	0.5	5.43b	5.61b	81.56b	84.73b	446.72b	478.46b	3.75b	4.02b
	1.0	5.65a	5.87a	88.47a	94.20a	505.97a	557.85a	4.25a	4.69a
UW	0.0	4.77d	5.01e	65.15e	71.58e	310.87e	358.86e	2.61e	3.01e
	0.5	5.03c	5.20d	70.83d	76.71d	356.63d	399.12d	3.00d	3.35d
	1.0	5.16c	5.39c	76.51c	83.77c	395.01c	451.26c	3.32c	3.79c
MTW	0.0	5.24c	5.36c	79.94c	83.37c	419.06c	446.60c	3.52c	3.75c
	0.5	5.82b	6.01b	92.28b	92.76b	536.80b	557.81b	4.51b	4.69b
	1.0	6.14a	6.35a	100.43a	104.63a	616.93a	664.44a	5.18a	5.58a

UW: Untreated water; MTW: Magnetically-treated water

CONCLUSION

In this study, squash plant growth characteristics such as plant height, number of leaves per plant, leaf area per plant, fresh biomass yield per plant, and dry biomass yield per plant were all enhanced by irrigation with magnetized water and foliar application of SWE. Chlorophyll a, b, and carotenoids content, mineral contents, and number of fruits per plant, fruit weight, yield per plant, and total yield were also enhanced. Therefore, we recommend that plants be irrigated with magnetic water and sprayed with SWE at a rate of 1 g L^{-1} under salinity stress because to the improved effects of magnetized irrigation water and SWE on the squash growth, yield and its components.

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تأثير الماء الممغنط ومستخلص الأعشاب البحرية على نمو ومحصول نباتات الكوسة المنزرعة تحت الظروف الملحية

منصور السيد رمضان* وأسامة عبد السلام شلبي
قسم الإنتاج النباتي، مركز بحوث الصحراء، مصر

الملوحة من أهم الإجهادات البيئية التي تؤثر على إنتاجية المحاصيل في جميع أنحاء العالم. يعد المجال المغناطيسي ومستخلص الأعشاب البحرية من الطرق الفعالة لزيادة قدرة النباتات على تحمل الظروف البيئية المغايرة مما يؤدي إلى زيادة إنتاجيتها. أجريت هذه الدراسة بالمحطة البحثية التابعة لمركز بحوث الصحراء، رأس سدر، محافظة جنوب سيناء، مصر خلال صيف موسمي ٢٠٢٢ و٢٠٢٣ بهدف دراسة تأثير مياه الري الممغنطة (مياه ري غير معاملة ومياه ري ممغنطة) والرش بمستويات مختلفة من مستخلص الأعشاب البحرية (صفر، ٠.٥ و١ جرام/لتر) على النمو والمحصول ومحتوى الكلوروفيل ومحتوى العناصر المعدنية لنباتات الكوسة تحت الظروف الملحية. أظهرت النتائج زيادة صفات النمو الخضري، ومحتوى الكلوروفيل ومحتوى الأوراق من النيتروجين، الفوسفور والبوتاسيوم، وزيادة المحصول ومكوناته مع الري بالماء الممغنط والرش بمستخلص الأعشاب البحرية، في حين أنخفض محتوى الصوديوم ونسبة الصوديوم/البوتاسيوم باستخدام الري بالماء الممغنط والرش بمستخلص الأعشاب البحرية. تم الحصول على أفضل النتائج من حيث النمو الخضري والمحصول ومحتوى النباتات من الكلوروفيل والعناصر المعدنية من معاملة الري بالماء الممغنط مع الرش بمستخلص الأعشاب البحرية بمعدل ١ جرام/لتر. الخلاصة: المعالجة المغناطيسية لمياه الري المالحة والرش بمستخلص الأعشاب البحرية حسنت من صفات النمو ومحصول الكوسة ومكوناته تحت ظروف الإجهاد الملحي.