

Full Length Research Paper

***Citrullus lanatus* plant response to irrigation water magnetized in sandy soil**

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Received 21 November 2022; Accepted 31 March, 2023

In this study, the productivity of the red watermelon (*Citrullus lanatus*) crop in arid regions with saline water is examined in relation to the effects of magnetic treatment of irrigation water. The greenhouse experiments compared two treatments (magnetic treatment of irrigation water) and (no magnetic treatment of irrigation water). Magnetic treatment device delta water with a power of 14500 gauss (1.45 T) that was delivered from the company professional hydraulic (CPH) was used for vegetative traits on growing periods and quantitative, qualitative, and chemical production characteristics at maturity. The leaf area and the number of seedlings treated with magnetic water (MW) increased significantly by 8.7 and 1.4%, respectively, compared to control seedlings. Leaf holder length also decreased. Except for plant height prior to branching, it also demonstrated a notable increase in stem characteristics. Magnetic water (MW) enhanced the yield characteristics (quantitative, qualitative, and chemical), resulting in increases in the number of fruits produced per plant 11.4%, fruit weight 2%, the weight of a kilogram of seeds, and yield, respectively with 0.34, 10.34 and 16.5% decrease in fruit peel thickness. Additionally, it revealed that the sugar content had increased by 15.4% and that the acidity and electrical conductivity (EC) had changed. By adding magnetic treatment to irrigation water, fruits ripen earlier and have better texture, traceability and homogeneity.

Key words: Magnetic water, *Citrullus lanatus*, productivity, irrigation.

INTRODUCTION

Salinity is one of the main obstacles to plant development and productivity, and agricultural production is the cornerstone of preserving both personal income and food security (Lam et al., 2022). The majority of the world's dry and semi-arid lands lack irrigation water, and one of the effects of using saline groundwater for irrigation is

salinization (Acosta-Motos et al., 2017; Majeed and Muhammad, 2019), which affects more than a third of the lands irrigated with groundwater (Foster et al., 2018). According to Eswar et al. (2021) and Jumman et al. (2022) and other researchers, the effects were caused by farmers' ignorance of the mechanisms underlying water

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exploitation.

As a result of the salinization of irrigation water and the expansion of saline lands, plants are subject to saline stresses related to toxicity and ion balance, such as Na and Cl, and reduce the efficiency of irrigation water (Dustgeer et al., 2021), in addition to oxidative stress (Acosta-Motos et al., 2017). This in turn restricts the variety of crops, the quantity and quality of production, and consequently the economic level (Zörb et al., 2019). About 45% of the country's agricultural output is produced in the El Oued region of Algeria's desert, ranking it first overall. Its reliance on irrigation from groundwater, the majority of which is salty, jeopardizes the region's ability to sustain agriculture as well as the condition of the land used for agriculture (Aliku, 2017).

Several techniques were found to confront the problem of salinity and improve the agricultural sector in terms of quantity and quality, including nanofiltration, reverse osmosis, and membrane distillation (Duong et al., 2015; Quist-Jensen et al., 2015). One of the modern techniques is the magnetic treatment of irrigation water (Ali et al., 2014), which is one of the simplest and easiest techniques. The magnetism of water changes its physical and chemical properties, releasing salts, increasing solubility (Shi et al., 2022; Liu et al., 2019; Mghaiouini et al., 2020; Zhou et al., 2021), lowering surface tension, and dissolving large aggregates (Hamza, 2019). This causes the water to become more dynamic and swifter within the soil horizon, reaching the absorption areas and enhancing its absorption by the plant, which impacts plant development and growth (Zúñiga et al., 2016).

Hence, magnetized water can maintain soil sustainability and increase plant production and quality. According to studies, magnetized water boosts the effectiveness of fertilizers and water, removes sediment from soil or pipe surfaces, and dissolves hard and few salts, enhancing the activity of soil microorganisms, soil nutrition, and plant resistance to environmental factors (Alattar et al., 2022). Due to the high temperatures in late spring, the valley area's early watermelon production was one of the most significant fruit crops. The region also has a diverse range of soil types and agricultural practices. The objective of this study was to determine the effects of irrigation water that had been magnetically treated and delivered by a delta water device on the development and characteristics of a red watermelon crop grown under controlled conditions on sand in Algeria's desert regions.

MATERIALS AND METHODS

The experiment occurred at the Hashemi Mesbahi farm in Sidi Aoun, El Oued State, Algeria (33°37' N, 6°53' W, 42 m altitude), and included 16 greenhouses with a combined area of 12000 m² between February and May of 2021 (Figure 1). The farm is located in an arid region where the temperature is high (annual average of 23°C), there is almost no precipitation, and the average rainfall is

83 mm, as well as low humidity ranges during the planting period between 11 and 30% (Khaled et al., 2019).

Using a delta water device with a power of 14500 gauss (1.45 T) that was delivered to the company professional hydraulic (CPH) complex in Algeria (CPH is Algerian company business, founded in 1985, specializing in the many fields and has various achievements, drinking water, sanitation, fire protection, home plumbing, gas, irrigation and solar systems). One of the greenhouses with a surface area of 12,000 m² was chosen from the farm and divided into two halves according to irrigation, with one part receiving normal water and the other magnetic water. On March 9, 2021, the feed plants for the red watermelon plant of the Ghali cultivar, El Galil, was cultivated from the type Bell-Grey, which is the product of the company Globale Syngenta, imported in Algeria by SRID (A trading company concerned agriculture, synergy resources innovation development) (<http://www.srid-dz.com/>), the identification of plant samples was confirmed by professor Youcef Helis from the Scientific and Technical Research Center on Arid Regions C.R.S.T.R.A Campus of Mohamed Khider University, Biskra Sciences, University El-Oued, Algeria (Figure 2).

The plots in each replication were regularly observed, and observations were taken from 3 randomly selected plants from each sub-treatment to measure vegetative traits on growing periods (the leaf area (cm²), number of leavers, leaf holder length, number of main stems, plant height, staircase length, length of branches, and number of flowers) and yield traits (the fruit weight, number of fruits per plant, the yield, and crust thickness) for the plants of red watermelon, *Citrullus lanatus*. Chlorophyll content was also measured according to the method described by Shiragave et al. (2015), and a Refractometer measured the sugar content with an ISOLAB mark, in addition to the pH and conductivity of the fruit pulp extract and measured soil and water properties. The statistical study was conducted to determine the significant differences between magnetic and non-magnetic water treatments by applying the t-test using the XLSTAT program.

RESULTS AND DISCUSSION

The soil properties

The red watermelon crop's cultivation also displayed changes in characteristics when irrigated with magnetically treated water. Both the M and NM treatments slightly raised the pH value from 7.67 to 7.7 and 7.85, respectively. The EC of the soil increased significantly in both the M and NM treatments by 26.3 and 44.2%, with the M treatment showing a higher increase of 14% in comparison to NM. Additionally, the organic matter content of the soil decreased by 154 and 281%, respectively, after irrigation with regular water or magnetized water. While the amount of nutrients (phosphorous and calcium) increased for the treatment of normal water by 72.8 and 9.59% and 41.12 and 13.55%, respectively, and the amount of Cl and Na increased for the treatment of magnetized water by 13.8 and 1.01%, respectively, compared to the amount for the treatment of normal water.

The effect of magnetic water had a significant effect on soil salinity; on the other hand, it had no significant effect on pH. This was demonstrated by Maheshwari and Harsharn (2009), who found that using magnetized water



Figure 1. The site of the Mesbahi Al-Hashemi farm.
Source: Google Earth (2021).



Figure 2. Installing a Delta water device and planting seedlings.
Source: Ghemam A. et al (2023)

for irrigation reduced soil acidity and increased electrical conductivity. This is in line with the findings of Hachicha et al. (2018) and Shahin et al. (2016). Likewise the increase in the soil content of P, Cl, and Ca by the moral effect of irrigation as a result of contributing to the liberation of elements from soil granules and the analysis of the organic matter, which was explained by the

difference between the estimation of organic matter at the beginning and end of the experiment, which was estimated at 3.81%, then it became 1.5% in the treatment of non-magnetized water and 1% in the treatment of magnetized water. It is worth noting that magnetized water has a higher effect (Table 1), and this is a result of changing the properties of water by magnetic treatment,

Table 1. Chemical and physical properties of soil used in the experimental.

Parameter	Soil natural after fertilization	Soil after watering with normal water	Soil after irrigation with magnetized water
pH	7.67	7.7	7.85
EC	0.95	1.2	1.37
CaCO ₃	12.92	14.15	14.67
MO (%)	3.71	1.5	1
P (ppm)	55.27	95.5	78
Cl (ppm)	nd	514.1	585
Na (ppm)	nd	93.27	94.3
Soil texture	Sand (%)		97.9
	Silt (%)		1.82
	Clay (%)		0.26

Source: Ghemam A. et al (2023).

Table 2. Chemical and physical properties of water used in the experimental.

Parameter	Unmagnetized irrigation water	Using magnetized irrigation water
pH	8	8.03
EC	5.68	5.7
P	0.76	3.51
Ca	400.8	501
Mg	271.66	255.2
Cl	1056.5	985.6
HCO ₃	97.6	103.7
TDS	3290	3270
TH	2200	2300
TUR	0.193	0.147
ST	0.073	0.024
D	1.005	1.004

pH= Potential hydrogen, EC = electrical conductivity, P = , Ca = calcium, HCO₃= bicarbonate, TDS = total dissolved salt, Mg = magnesium, Cl = chloride, TH= total hardness, TUR = turbidity, ST = Surface tension, D = density of water.

Source: Ghemam A. et al (2023)

especially surface tension and solubility (Mohamed and Sherif, 2020).

The water properties

The irrigation water analysis results in Table 2 show that it is characterized by alkaline acidity, higher salinity, and some mineral elements (Mg, HCO₃, and Ca). The outcomes also demonstrated that when exposed to a magnetic field, water's properties alter to varying degrees, either increasing or decreasing. The pH, EC, P, Ca, HCO₃, and TH increased, while the values of TDS,

Mg, Cl, TUR, ST, D decreased.

The effect of the magnetic field on the properties of chemical elements, molecules, and aggregates of water molecules is how we explain changes in water properties after magnetic treatment (Shimada, 2019). This effect increased phosphorous and carbonate ions in addition to calcium ions, which explains the slight change in pH and electrical conductivity. While we explain the decrease in the content of some elements, such as magnesium and chlorine, by the formation of salt compounds (Makulski, 2019), all of this leads to a change in the physical properties (TDS, TH, ST, TUR), which is consistent with what was approved by Alwedyani et al. (2015).

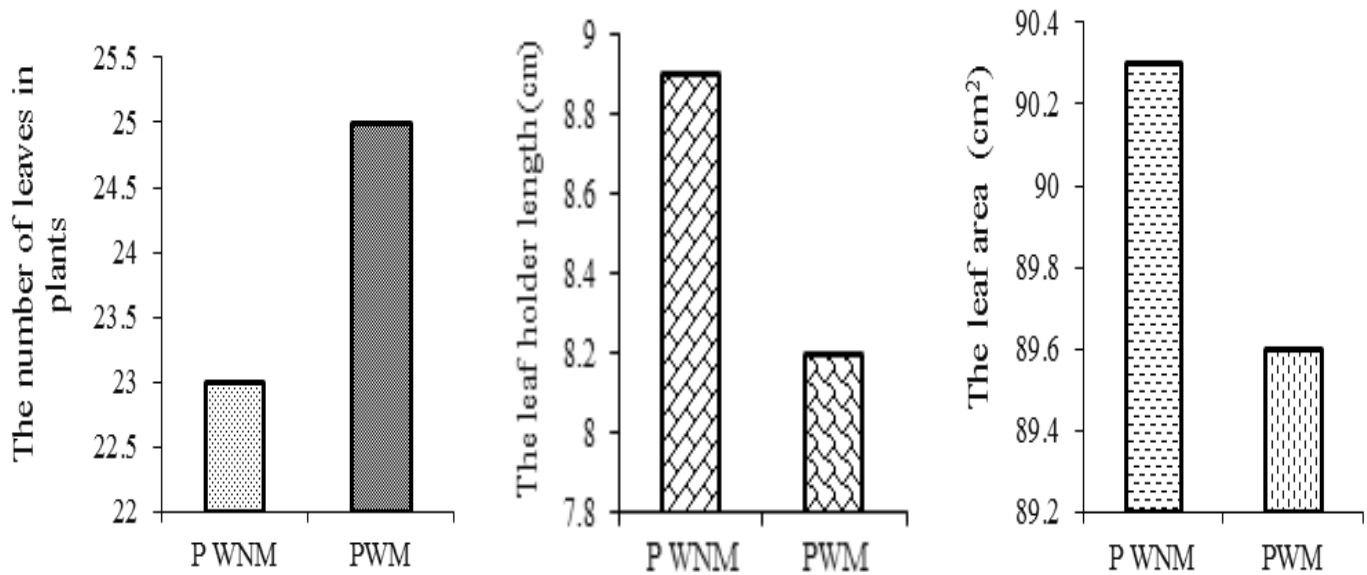


Figure 3. Effect of magnetically treated irrigation water on plant leaves characteristics.
Source: Ghemam A. et al (2023).

The effect of magnetically treated irrigation water on plant leaves

The main leaf indices of seedling growth (Figure 3) results revealed a significant increase in the number of leaves in plants (NL) irrigated with magnetized water, estimated at 10%, while was seen decreased by 1.4 and 8.5% in the leaf area (AL) and the leaf holder length (LHL), respectively, compared with non-magnetic water treatments.

The earlier research (Liu et al., 2019) revealed that the characteristics of plant leaves are either inhibited or stimulated by magnetized water. The findings agree in terms of the number of leaves with those stated by Alattar et al. (2019) reported that the potato, the strawberry produced a more significant number of leaves by watering plants with magnetically treated water when compared with those irrigated by watering plants with non-magnetically treated water. The proliferation in the number of leaves is due to the changes in magnetically treated water's chemical and physical properties (Alattar et al., 2020), also to the stimulating impact of the magnetic process (Alattar and Radwan, 2020), which increased the absorption of nutrients and accentuated the biological activity in plants (hormones and enzymes) and consequently influenced the growth of plants, including the number of leaves per plant (Mostafa, 2020).

The results agree with Alkhatib et al. (2020), but the shoot height (holder length) and leaf area contrast with those for increased leaf number according to Alattar et al. (2021), the inhibition of magnetically treated water on plant growth may be due to its impact on biochemical

processes, protein synthesis, and enzymatic activity.

The effect of magnetically treated irrigation water on the plant stems

The results of the main stem indexes of seedling growth (Table 3) showed a significant increase in the number of stems in plants (Ns) irrigated with magnetized water, estimated at 97.54%, while the decrease in the height of the main branch of the plant (HS) and the main branch length (LS) by 10.84 and 10%, respectively. The average length of the secondary branch (ALB) and the average length of staircases (ALS) improved by 8.34 and 9.6%, respectively, compared with non-magnetic water treatments.

The inhibition or stimulatory effect of watering with magnetized water on plant stem characteristics (plant height, height of the main branch) and (number of branches, average length of sub-pillars, length of peduncles), respectively, were compared to the control treatment. The increase in growth is because magnetization stimulates and activates nutrients in water and soil (Wang et al., 2018; Hassani et al., 2015; Ghernaout, 2018; Chibowski and Szcześ, 2018) in addition to the chemical and physical changes that occur in water and soil, which facilitate the plant's access to nutrients and activate strong reactions. In terms of height and length, this translates to the number of branches. The magnetized water accelerates plant growth and maturity, resulting in less height and early branching, which translates to the inhibitory effect. These results support the work of Mostafa (2020) in several crops

Table 3. Effect of magnetically treated irrigation water on plant stems characteristics.

Parameter	NS	H S	ALB	L S	AL S
P WNM	1.62	15.64	163	87.5	5.22
PWM	3.2	14.11	176.6	79.5	5.72

Source: Ghemam A. et al (2023)

Table 4. Effect of magnetically treated irrigation water on yield characteristics.

Parameter	N F/P	MWF	CT	Y	W 1000
P WNM	11.77	8.8	1.15	52.83	10.62
PWM	13.11	9	0.96	58.33	10.71

Source: Ghemam A. et al (2023)

The effect of magnetically treated irrigation water on the yield

The obtained data (Table 4) have demonstrated that fruit number per plant, the fruit weight, the yield, peel thickness, and the weight of a thousand seeds were influenced by the application of irrigation with magnetized water, leading to a significant increase in the yield when compared with non-magnetic water treatments at 10.34%, the equivalent of 53.3 quintals. The watermelon used exhibited a significant response with regards to the number of fruits per plant for the magnetization of irrigation water at 11.4%, there was also no significant difference in the fruit weight and the weight of a thousand seeds. Also, the positive consequences showed a significant decrease in the thickness of the fruit's peel by 16.5%.

In line with the findings of Hamdy et al. (2015), the study revealed an increase in the quantity of early flowers and yield characteristics (1000-seed weight, total fruit yield, and number of fruits). The irrigation by magnetic water significantly increased seeds' weight and yield. Both provided an explanation of how magnetic water can increase a plant's internal energy and, consequently, the number of fruits that are produced. In addition to the number of fruits and the average weight of the fruit, as noted in our study, the dark and shiny color characterizes the fruits of the magnetized water treatment (Figure 4). Unlike the findings of Hamdy et al. (2015), the thickness of the fruit peels and as a result, its hardness were also decreased by irrigation with magnetized water.

The biochemical effects of magnetically treated irrigation water

The effects revealed that the chlorophyll content in leaves

was reduced by 23.1% by applying irrigation with magnetized water, whereas the sugar content was increased by 15.4% in fruits (Table 5). The positive results also showed a significantly reduced pH and EC for fruit pulp juice, ranging from 5.48 to 4.75 mmho/cm, which were 5.36 and 5.03 mmho/cm¹, respectively.

When irrigation water is exposed to the magnetic field, it changes its physical, chemical, and electrical properties, which in turn affects its behavior in the plant and the subsequent production characteristics of acidity, conductivity, chemical content, and medicinal activity (Wang et al., 2018; Alavi et al., 2020), therefore modifying the acidity and conductivity of red watermelon juice and increasing its sugar content. This result is consistent with the work of Ali et al. (2019), it revealed that the magnetic water treatment excelled in all the studied traits on growth and yield of melon cv. Piel de sapo. Reduced electrical conductivity, decreased sodium uptake by plant cells, decreased effects of water magnetization salinity build-up in plants, and increased nutrient content are all (Alattar and Radwan, 2020). The qualitative characteristics showed that the fruits of plants irrigated with magnetic irrigation water had a luster and a dark green color and were more homogeneous in size (Figure 4) in addition to their early maturity and good taste. Where the tasting results were, 86% preferred the fruits of the magnetic water and only 14% admitted that there was no difference.

Conclusion

This research supported the idea that using magnetized irrigation water in agriculture can help reduce the effects of irrigation water salinity on plant growth and production because it improved both the quality and quantity of the red watermelon crop's production and even its



Figure 4. The color comparison of *Citrullus lanatus* fruits irrigated with magnetized and normal water.

Source: Ghemam A. et al 2023

Table 5. Effect of magnetically treated irrigation water on biochemical characteristics.

Parameter	Chlorophyll	Sugar	pH	EC
P WNM	0.32	8.46	5.36	5.03
PWM	0.26	9.76	5.48	4.75

Source: Ghemam A. et al (2023)

marketability. The crop was grown in sandy soil inside greenhouses. According to the study's findings, this kind of research could be applied to a wide range of crops and salinity-related stresses.

CONFLICTS OF INTERESTS

The authors have not declared any conflicts of interests.

ACKNOWLEDGEMENT

This study was funded by the Hashemi Mesbahi investor and the CPH complex in Algeria.

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