International Journal of Agricultural Research and Review
Abbreviated Key Title: Int. J. Agric. Res Rev.
ISSN: 2360-7971 (Print) & Open Access
DOI: 10.54978/ijarr.2023. v11: 4, Pp: 30-37

Volume-11 | Issue-4| April, 2023| ***Full length Research Paper***

Assessment of the impact of magnetically treated water on the growth and productivity of greenhouse off-soil crops

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***Corresponding author:** Bali M | **Accepted:** 21/4/2023 | **Published:** 23/4/2023 |

Abstract: Magnetic fields are known to induce biochemical changes and may be used to stimulate crop growth-related reactions. An experimental study was carried out by the Technical Center for Protected and Geothermal Cultures (CTCP) which makes it possible to study the possibility of using drainage water for the irrigation of aboveground crops in greenhouses. To study the impact of magnetized water on tomato growth and productivity, the crops were irrigated with water passing through a magnetic field. The results showed that magnetized water irrigation has a significant positive effect on all morphological parameters examined. Magnetically treated water could be used to improve the growth and productivity of greenhouse crops.

Key words: Crops, Greenhouse, Growth, magnetic water treatment, Impact, Irrigation

Citation: Dalaous and Bali (2023): Assessment of the impact of magnetically treated water on the growth and productivity of greenhouse off-soil crops. *Int. J. Agric. Res Rev.* 11(4) Pp 30—37, 2023.

Journal Name
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1. INTRODUCTION

The effects of magnetic treatment on water quality have been observed for several years. This technology has been used mainly in countries that have very few chemicals. Since 1980, a little were known about how the magnetic field could stimulate or even inhibit plant growth. Wojcik (1995) was the first to report that stationary magnetic fields can enhance and accelerate plant growth. According to Jones et al. (1986), Magnetic fields have been reported to exert a positive effect on plant growth and development (De Souza et al. 1999; Martínez et al. 2000), tree growth (Ruzic et al. 1998), on fruit and vegetable ripening (Boe and Salunke 1963), and on crop yield (Pietruszewski, 1993). Some review articles also mention a number of controversial primary results (Findlay, Hope 1976; Frey, 1993). According to Yakovlev et al. (1990) and Cakmak et al. (2009), Magnetic water treatment can reduce soil alkalinity, and can increase crop yields and earlier growing season. However, in Egypt, the available studies and the application of this technology in agriculture are very limited. Therefore, the present work aims to study the effect of irrigation with magnetized and non-magnetized drainage water on the growth and yield of tomato in greenhouse and soilless.

2. MATERIAL AND METHODS

The experiment is carried out in an aboveground greenhouse of 30 meters long and 9.5 meters wide. This greenhouse is used to cultivate tomato. The plants are arranged in five rows equidistant by 1 meter and the distance between two plants is about 40cm. Each row contains 66 plants; that is to say that the greenhouse contains 330 plants. The tests were developed on seedlings of the same variety (*Solanum lycopersicum*) obtained from the stage harvest bouquet number 5 and flower bouquet number 6. The seedlings were irrigated four times a day and each received 2000ml/day at the rate of 50ml/2h. For each type of irrigation, we used 5 plants (3 types of water x 5 plants = 15 plants). The plants were selected from the same substrate of a mixture of compost + perlite + sand at a thickness of 30cm supported by a layer of gravel of 5cm. A follow-up of the growth of tomato plants was undertaken in order to determine the morphological parameters of the plants irrigated by different types of water (groundwater, untreated drainage water, treated drainage water). The physico-chemical characteristics of these waters are dipected in the table 1.

The parameters used to assess the impact of drainage water on the development and yield of the plant are as follows:

- Number of leaves
- Stem diameter (cm)
- Number of flowers / bunch
- Number of bunches
- Amount of fruit.

3. RESULTS AND DISCUSSION

3.1. Monitoring the growth of tomato plants

The growth of tomato plants refers to the irreversible quantitative and qualitative changes that occur in the plant over time. Indeed, the monitoring of the behavior of plants facing irrigation by magnetized and non-magnetized water was based on several morphological parameters. A study was done to examine the significance between magnetic and non-magnetic water treatments of all the characters (Number of leaves, stem diameter (cm), Number of flowers / bunch, Number of bunches, Amount of fruit) under study.

a- The number of sheets (NF)

Figure 1 shows the evolution of the number of foliar plants irrigated with the untreated drainage water and the treated drainage water and the groundwater (water reference) as a function of time. The results indicate that the average leaf yield of tomatoes irrigated with non-magnetized water decreases over time from 42 to 47 leaves/plant (Fig. 3b) due to high salinity compared to that of plants irrigated with salt. and for magnetized water which generates leaf area growth of 60-64 leaves/plant (Fig. 3c) almost similar to the number of leaves irrigated by the groundwater which records 60-67 leaves/plant (Fig. 3a). These results can be obtained due to the effect of the magnetic field on the alteration of key cellular processes such as the transcription of genes which play an important role in modifying cellular processes. In this regard, Tian et al. (1991) and Atak et al. (2000) who found an increase in chlorophyll content that appeared specifically after exposure to a magnetic field for a short period. Additionally, Atak et al. (2003) suggested that by increasing all photosynthetic pigments through MF-induced increase in cytokinin synthesis. They also added cytokinin which plays an important role on chloroplast development, shoot formation, axillary bud growth, and induction of the number of genes involved in chloroplast development nutrient metabolism. This also may be due to the increase in growth promoters (IAA) . Similar results were observed on rice and chickpea when irrigated with magnetic water (Tian et al. 1991; Nasher, 2008). As good as enhancement of photosynthetic pigments have been recorded in species of Paulowria (Atak et al. 2000), sunflower (Oldacay, 2002), soybean (Atak et al. 2003) when seeds or explants exposed to field (3.8 – 4 .8 mt) for a short time.

b- Stem diameter

There are significant increases in plant stem diameter occurred when plants were irrigated with magnetically treated water which recorded 0.80-0.85 cm, for control plants 0.82-0.85 cm and again plants irrigated with untreated drainage water of 0.82-0.85cm (Figure 2). As the salinity level of irrigation water increased, plant stem diameter increased significantly over time for all different types of irrigation water Figures 2 (a,b and c). The use of magnetized irrigation water also improved plant stem diameter and plant dry weight. Previous studies on different crops such as lentil (Qados, Hozayn, 2010, snow pea and chickpea (Grewal, Maheshwari, 2011) and tomato (Mohamed, 2013), revealed an increase in fresh and dry weight of plants irrigated with magnetized water Improved treatment of irrigation water by vegetative growth of the magnetic field (El-Yazied et al. 2012) and resulted in taller and heavier plants and increased yield and yield elements of several crops (Hozayn, 2011). Indeed, Hameda (2014). has suggested

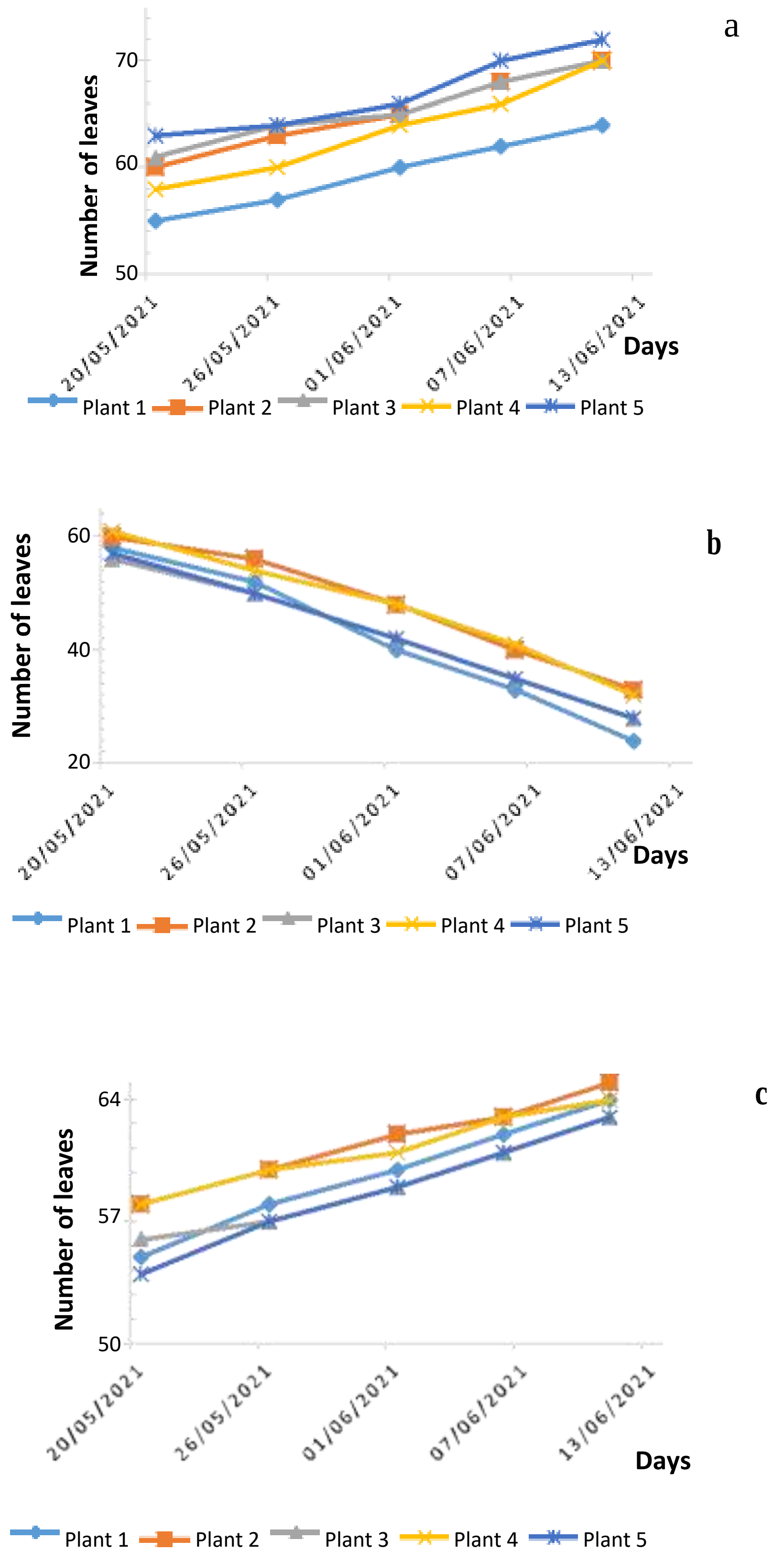


Fig. 1. Evolution of the number of leaves of plants irrigated by ground water (**a**), non-magnetized drainage water (**b**) and magnetized drainage water (**c**)

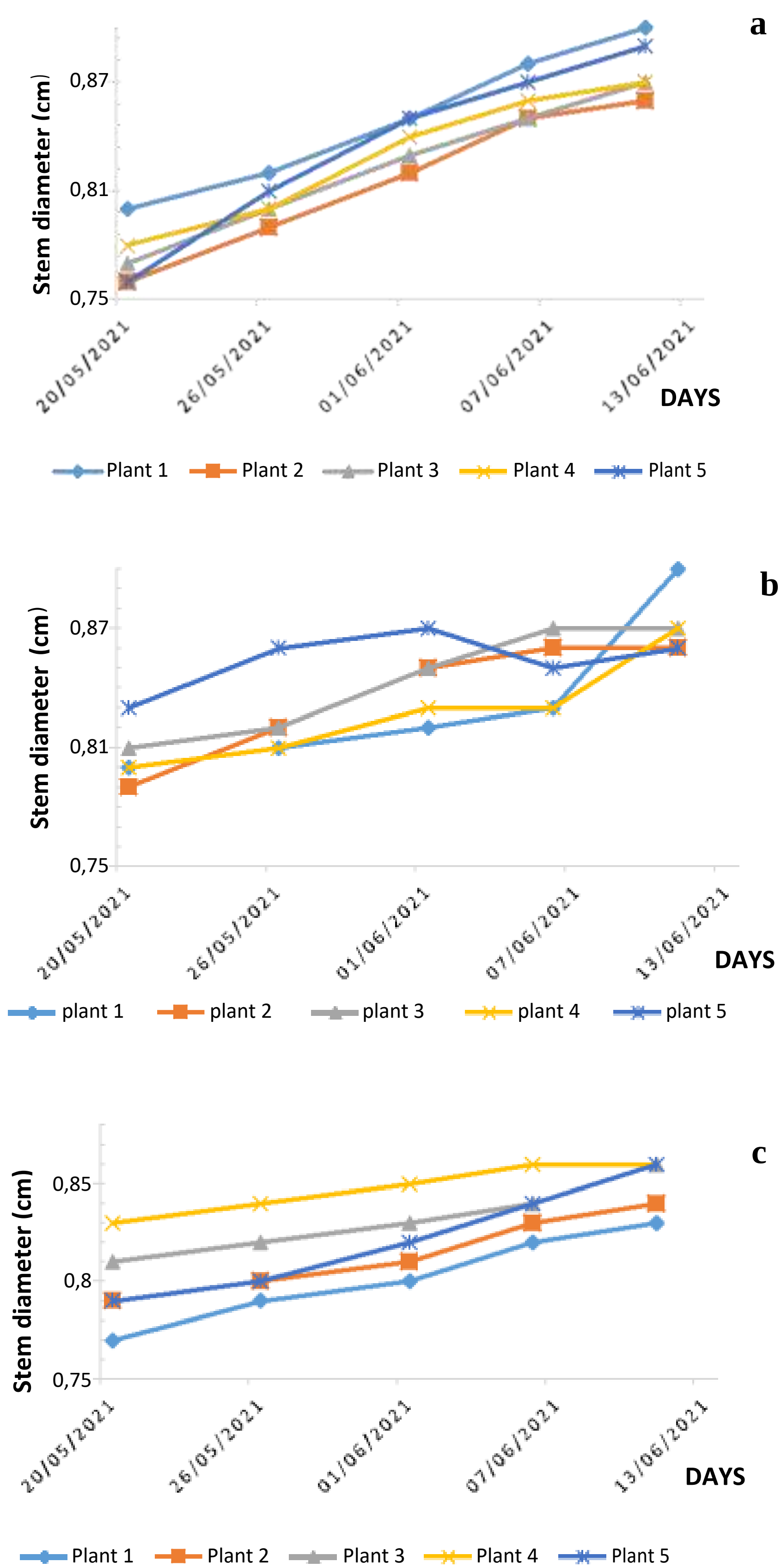
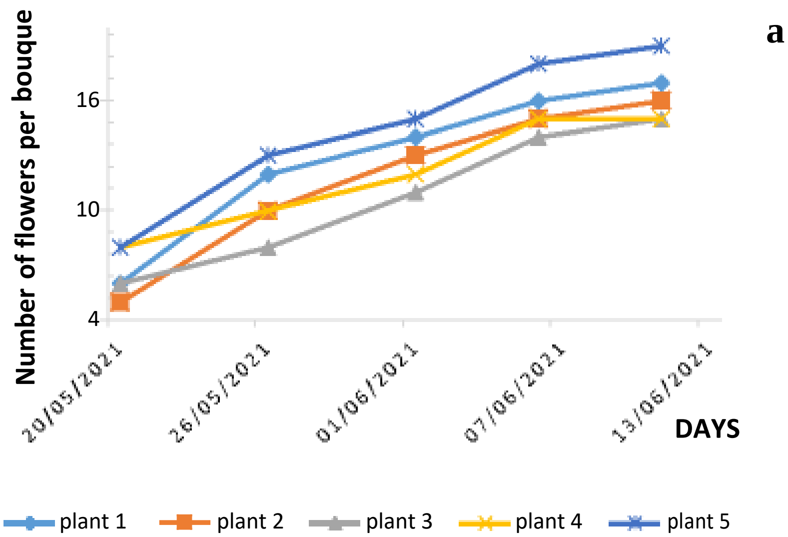


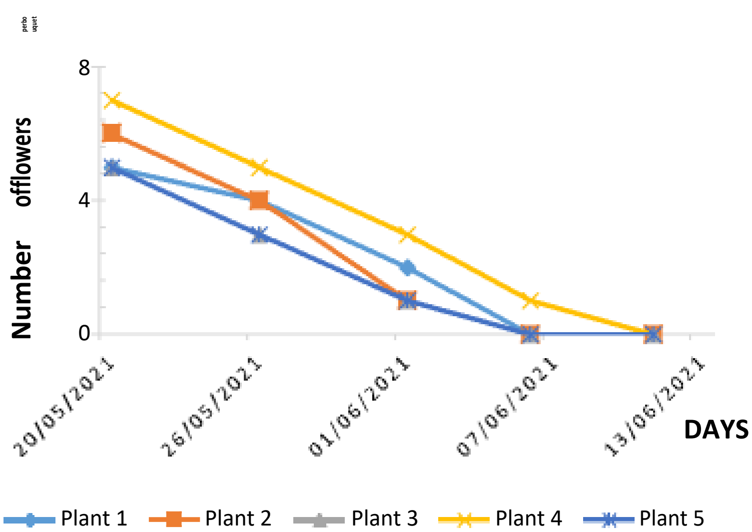
Fig. 2. Evolution of stem diameter of plants irrigated by ground water (**a**), non-magnetized drainage water (**b**) and magnetized drainage water (**c**)

that improved stem growth may be related to accelerated root growth and stomatal conductance. However, the authors observed that plants react to treated water by producing more root hairs (Taimourya et al. 2015; Brissier et al. 2005).

c- Number of flowers per bouquet

Concerning the number of flowers per bouquet, an average number of flowers of the control plants of 13 flowers/plant (Fig. 3a), the plants irrigated by untreated water record 2 flowers/plant as a function of time (Fig. 3b) compared to that of plants irrigated with magnetized water which shows a progressive increase of 8 flowers/plant (Fig. 3c). However, this increase remains lower than that of the number of flowers of the plants irrigated by the groundwater. Thus irrigation with treated water allows the appearance of flowers in a normal way than irrigation with non-magnetized water which causes a significant decrease over time due to the accumulation of precipitates at soil level. and renders the plant unable to absorb nutrients, hence the cessation of flowering. This improvement can be attributed to the activation of phytohormone production which affects the enhancement of cellular activity (Maheshwari, Grewal, 2009). In contrast, Hozayn and Abdul Qados (2010) and Turker et al. (2007) noted the formation of new protein bands. Also, Çelik et al. (2008), Shabrang and Majd (2009) reported that this physical treatment affects gene expression by increasing biological responses like protein synthesis.





c

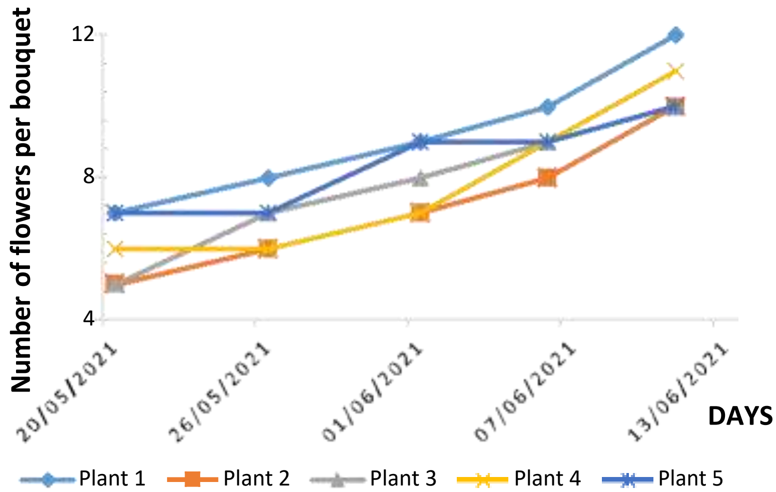
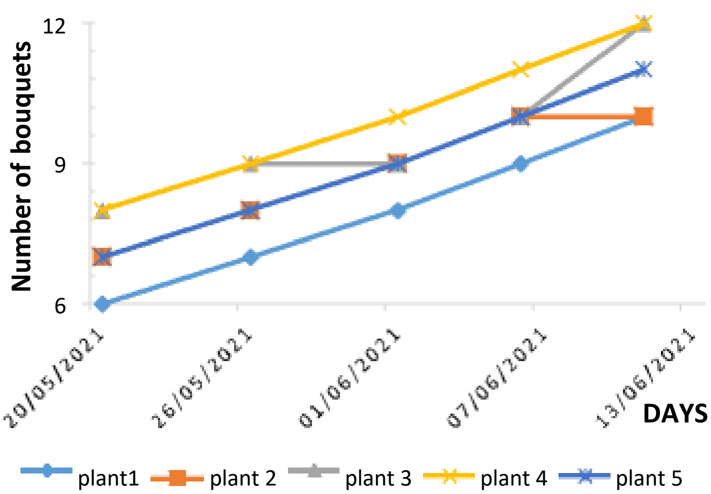


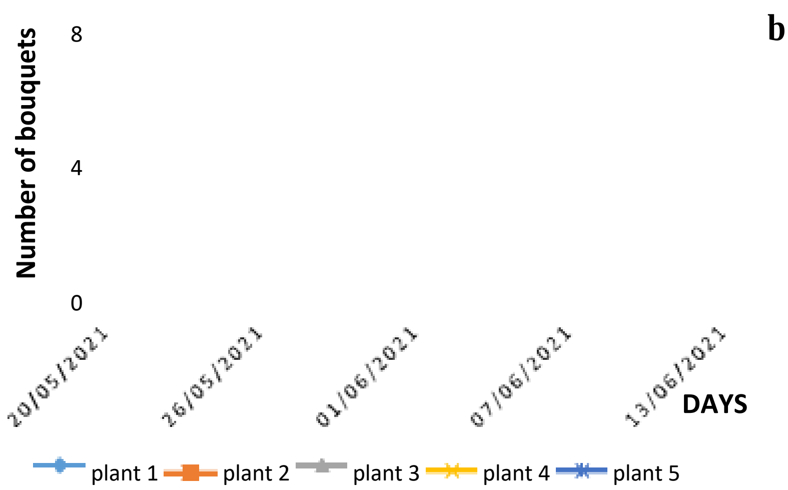
Fig. 3. Evolution of the number of flowers per bouquet of plants irrigated by ground water (**a**), non-magnetized drainage water (**b**) and magnetized drainage water (**c**

d- Number of bouquet

Figure 6 presents the evolution of the number of plant clumps irrigated by groundwater, untreated drainage water and magnetization treated drainage water. The results of irrigation with non-magnetized water induce a remarkable decrease in the number of bunches over time, which records an average of 4 bunches/plant (Fig. 4b). While an increase in the occurrence of plant clumps irrigated with magnetized water by 9 clumps/plant (Fig. 4c). The number of bunches of plants irrigated by irrigation water is 9 bunches/plant (Fig. 4a). Tomato plants irrigated with treated water contained clumps, while tomato plants irrigated with non-magnetically treated water had very few clumps. In this regard, Celik et al. (2008) found that the increase in plant regeneration percentage is due to the effect of magnetic field on cell division and protein synthesis in paulownia knot cultures. Shabrangi and Majd (2009) concluded that increasing biomass requires metabolic changes, especially increased protein biosynthesis. Therefore, magnetic technology improves water quality like pH, salt solubility, surface tension and conductivity (Grewal, Maheshwari, 2011) affects cell membrane structures and increases their permeability and their transportation. Ions through ion channels, which influence different activities of metabolic pathways (Balouchi, Sanavy, 2009) through increased synthesis of cytokinins which plays an important role in chloroplast development, shoot formation, growth axillary buds and the induction of a number of genes involved in nutrient metabolism of chloroplast development.

a





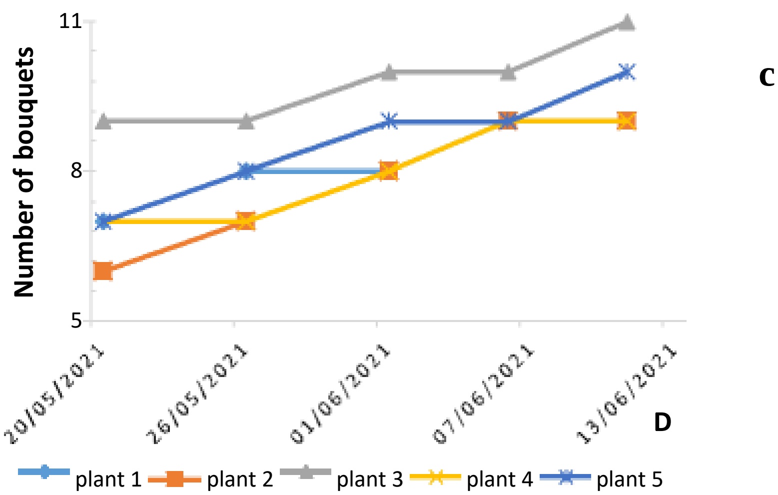
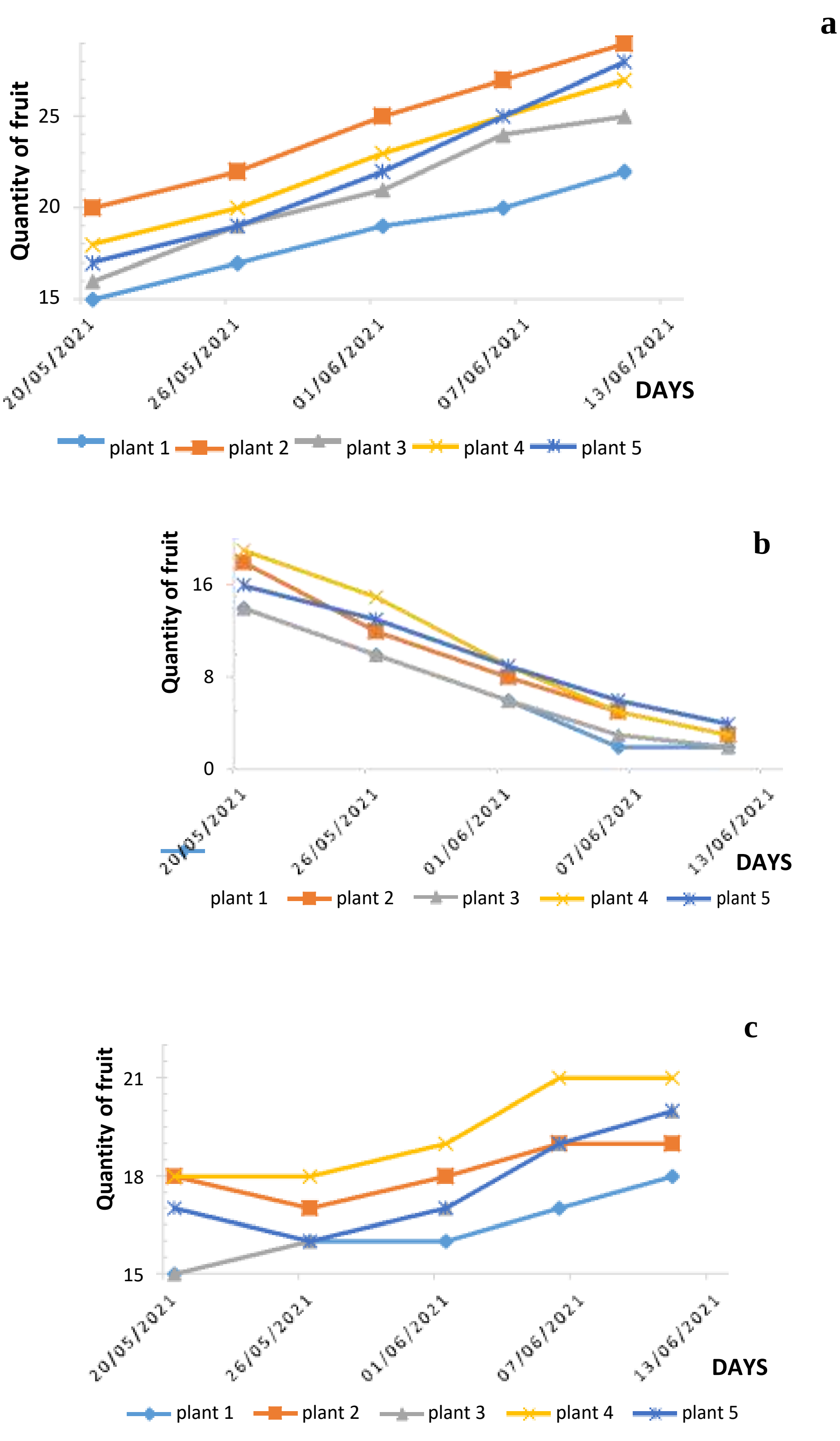


Fig. 4. Evolution of the number of bouquets per plant irrigated by ground water (**a**), non-magnetized drainage water (**b**) and magnetized drainage water (**c**)

e- Fruit quantity

Figure 5 depicts the evolution of the fruit quantity as function of irrigation water types. Results showed that there is significant difference in the number of fruits/plant for the types of irrigation water, the average fruit amount of plants increased significantly when the plants were irrigated with water. Magnetically treated 17-19 tomatoes/plant compared to plants irrigated with untreated water 7-10 tomatoes/plant respectively with 19-25 tomatoes/plant irrigated with the groundwater. The increase in the salinity of irrigation water significantly decreased the number of fruits per plant. Our results are like those obtained by other researchers. Reina et al. (2001) found a significance of increasing water absorption rate with increasing magnetic force. While irrigation with high saline water may be due to osmotic stress in the crop with reduced plant growth and yield, ion toxicity and/or cell division inhibition (Romero-Aranda et al. 2011) Salinity caused significant retardation of crop growth and yield. In this context, Nasher (2008) found that plants irrigated with magnetized water were higher than plants irrigated with unmagnetized water and this increase was reported by the significant increases in pigment fractions recorded in chicks of pea plants irrigated with magnetized water compared to the control treatment. The use of magnetically treated irrigation water did not significantly modify the number of fruits. These results indicated that



water magnetization is an effective technique to improve the yield of irrigated crops where highly saline water can be used. This method can be used to mitigate the negative impact of saline irrigation water on the crop productivity.

4. CONCLUSION

Results showed that salinity affects the crop growth as well as their physiological parameters. Magnetically treated water helps to mitigate the adverse effects of water stress on growth, development and crop yield. This study confirmed the positive effects of magnetic water treatment on the growth and productivity of crops. The results indicated that magnetised drainage water can be used as an alternative to irrigate greenhouse crops.

ACKNOWLEDGMENT

The authors gratefully acknowledge the financial support provided by GMX International Corporation, USA and Amiral-agro, Tunisia.

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