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RESEARCH ARTICLE

Effect of Magnetically Treated Water on the Growth and Yield of Tomato (*Solanum lycopersicum*) in Aquaponics System

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Abstract

Objectives: This study investigated the effect of magnetized water (MW) treatment on the growth and yield parameters of tomatoes, such as plant height, the number of flowers and fruits developed, and the weight of the fruits in aquaponics system. **Methods:** Permanent (N52 cuboid) magnets of 2 cm x 1 cm x 0.5 cm were assembled, arranged alternately, and installed along the inlet pipe using an industrial-grade adhesive tape to achieve magnetization in the aquaponics set-up. The experiment considered a single-factor experiment with three levels (control – no magnetic device, magnetic device with six magnets, and magnetic device with twelve magnets), replicated three times, and arranged in a completely randomized design. **Findings:** Tomatoes when irrigated with magnetically treated water in an aquaponics system showed a significant increase in growth and yield parameters. The plant height and weight of tomato fruits increased by 56.41% ($p < 0.01$) and 64.12% ($p<0.05$), respectively, when compared to the control. In addition, tomatoes irrigated with MW using a magnetic device with 12 magnets recorded the highest plant height, the number of flowers, the number of fruits, and the weight. Furthermore, the plant height, the number of flowers and fruits, and the weight of the fruits increased as the number of magnets in the magnetic device increased. **Novelty:** The integrated application of magnetically treated water in an aquaponics system has not been extensively studied. By focusing on the agronomic response of tomatoes, this study provides useful insight that could improve efficiency, contributing to sustainable production in limited spaces.

Keywords: Magnetically Treated Water; Aquaponics; Tomato; Plant Growth; Yield Enhancement

1 Introduction

Aquaponics integrate aquaculture and plants in a recirculating system, in which nutrients from wastewater generated by its feces are absorbed by hydroponically grown plants through direct excretion as well as the microbial breakdown of organic residues. It is also gaining prominence in bio-integrated food production [1]. This food-growing platform is natural, organic, and good for the environment, as it incorporates the best features of hydroponics and aquaculture without wasting water or synthetic fertilizer. While aquaponics is an efficient system for food production, recent studies suggest that when paired with magnetic water treatment, a technique proven to enhance plant growth and yield, this method offers a promising approach to addressing global food production challenges.

Water magnetization, a promising physical water treatment, helps sustain a supply of clean, fresh water, mitigate the effect of climate change on crop production, and clean up soil and water contamination [2]. This treatment enhances structural order through hydrogen-bonded networks of water molecules, which are a result of quantum physics and chemical factors [3]. Researchers conducted several studies to explore its application in agriculture, water management, and soil and water remediation, revealing a positive impact on the agronomic characteristics of crops. The application of magnetically treated water as irrigation resulted in a recorded increase in plant height, number of branches, and a 17% increase in eggplant yield [4]. Furthermore, a significant improvement in nutrient mobility and absorption is evident in the increased concentration of nitrogen and phosphorus in the leaves, which in turn induces higher nitrogen assimilation, leading to increases in growth and yield parameters for lettuce [5] and an increase in yield and fruit quality for tomatoes [6] . While magnetically treated water has been gaining traction in traditional soil-based agriculture and hydroponics, limited studies have been conducted on the application of this technology to aquaponics, despite its potential.

On the other hand, tomatoes, an important crop for food security, have been shown to respond positively to magnetic water treatment in soil-based cultivation, with studies indicating improvements in vegetative growth, stem diameter, fruit yield [7], seed germination, and productivity [8]. In addition, tomatoes grown under magnetically treated water in hydroponics showed significant increases in chlorophyll content, photosynthesis, transpiration, fresh biomass, number of fruits, and root dry biomass [9]. Integrating this technique within an aquaponics system offers an innovative approach to maximizing resource efficiency and enhancing crop productivity.

Food security, water scarcity, and plant pollution, as well as high energy use, are issues that the global population is struggling to cope with, and the combination of these technological advances could be an alternative to such concerns. In order to maximize these potentials, the application of this technology to integrated systems, such as aquaponics, along with emerging technologies, such as magnetic water treatment, offers solutions for sustainable food production, water conservation, and nutrient use. This study tries to address a gap in how magnetically treated water affects the growth and yield of tomatoes in an aquaponics system. Specifically, it aims to determine the growth and yield of tomatoes in terms of plant height (cm), number of flowers, number of fruits, and fruit weight (g).

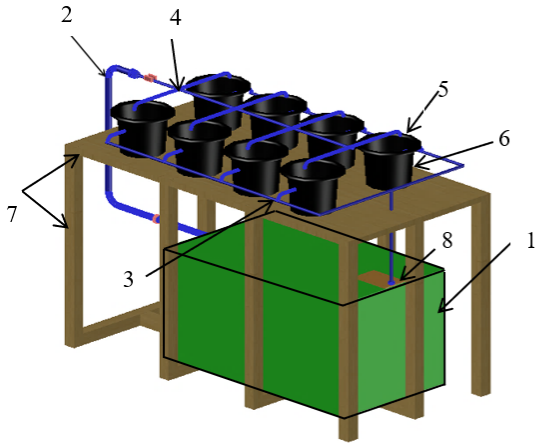
2 Methodology

2.1 The Experimental Set-up

The experimental setup of the study shown in Figure 1 was established in the experimental area of the College of Engineering, Cagayan State University - Sanchez Mira Campus, Cagayan Province, Philippines. Nile tilapia (Oreochromis niloticus) weighing approximately 1.5 kg were stocked in a rectangular box with dimensions of 78.74 cm x 54.61 cm x 50.8 cm, which had a capacity of 0.155 m^3, where tilapia fish were grown. A 2.54 cm diameter pipe was used to convey and discharge irrigation water through a water pump for tomato plants transplanted in a grow bucket. The filtration process occurs before the water is discharged from the growing buckets and flows back into the fish tank.

2.2 Magnetization

Permanent (N52 cuboid) magnets with dimensions of 2 cm x 1 cm x 0.5 cm were assembled, arranged alternately, and installed along the inlet pipe using industrial-grade adhesive tape. As the irrigation water was conveyed through the inlet pipe, magnetization was achieved before it was immersed in the grow buckets as magnetically treated water, where tomatoes were planted.



Code	Description
1	Fish Tank
2	Inlet Pipe
3	Outlet Pipe
4	Pipe
5	Hose
6	Grow Bucket
7	Frame
8	Filter

Fig 1. The design of the experimental set-up

2.3 Experimental Design, Treatment and Statistical Analysis

All data were evaluated using single-factor experiments with a completely randomized design. If there were significant variations between the treatment means, analysis of variance was used. Moreover, differences among treatment means were analyzed using the least significant difference (LSD) method. The treatments applied in this study involved three varying numbers of magnets: T_1 (control – no magnetic device), T_2 (a magnetic device with 6 magnets), and T_3 (a magnetic device with 12 magnets). All treatments were replicated three times.

2.4 Data Collection

Agronomic traits of tomatoes, such as plant height, the number of flowers and fruit-bearing, and the weight of fruit-bearing, were collected. The experiment utilized a digital weighing scale and straight-edge ruler for measurements. The weight of the fruit bearings was measured with a weighing scale, and the height of the tomato plants was measured with a straight-edge ruler. Weekly measurements and records of plant height, the number of flowers and fruit count, and transplanting to harvesting were made.

3 Results and Discussion

3.1 Growth Parameter

The weekly height of tomatoes (cm) cultivated in an aquaponic system in response to the use of magnetically treated water for 105 days following transplanting (DAT) is depicted in Table 1. The table also shows that 7 to 21 DAT increased plant height; however, the number of magnets present had no apparent effect on plant height, as revealed by the Analysis of Variance. This further implies that plant height in the first 21 days after transplanting was relatively uniform. The absence of significant differences in plant height during the first 21 days might be attributed to the early phase of root establishment and acclimatization to the aquaponic environment, where the impact of magnetically treated water may still need to be fully realized.

On the other hand, the positive effect of magnets on tomato height began at 28 DAT, with a significant increase of 28.83% in plant height ($p < 0.05$) and this finding was observed until the 84th day after transplanting with a 56.41% ($p < 0.01$) increase in plant height. This significant increase in plant height observed after 28 days may be due to the alteration of the physical properties of water, such as reducing surface tension, increasing ion solubility, or enhancing the interaction of water with plant root systems, which could improve nutrient absorption and overall growth as cited by Dawa et al., (2018) [10]. Moreover, a comparison using Least Significant Difference (LSD) further confirmed that tomato plants irrigated with water treated with twelve permanent magnets showed a significant difference in height compared to both the control group and the group treated with six magnets. In addition, the results further reflected a direct relationship between the height of tomatoes at weekly intervals and the number

of magnets present in each treatment, as reflected in Chart 1. This means that as the number of magnets increases, the height of the tomatoes increases.

The utilization of MW in response to the plant height used in the study is in favor of several studies conducted. This study recorded a 56.41% increase in plant height as compared to a 10.66% increase in plant height of lettuce recorded by Agcaoili (2019)[11]. In addition, Galvan et al. (2021)[12] recorded a 24.7% increase in the plant height of pechay while a 9.6% increase in the plant height of eggplants under hard water (Kishore et al., 2022)[13].

Table 1. The effect of using magnetically treated water on the height (in cm) of tomatoes in aquaponics system

Treatment	Number of Days after Transplanting															
	0 DAT	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT	91 DAT	98 DAT	105 DAT
T1	4.4	6.9	9.5	11.9	16.3^{a}	20.9^{a}	24.5^{a}	29.3^{a}	41.6^{a}	46.3^{a}	51.5^{a}	57.2^{a}	59.0^{a}	60.7^{a}	67.2^{a}	72.5^{a}
T2	4.2	6.6	9.5	12.5	17.8^{a}	24.1^{b}	28.1^{ab}	35.3^{a}	49.5^{a}	56.0^{a}	62.9^{a}	68.5^{a}	69.7^{a}	71.1^{a}	74.1^{a}	83.3^{a}
T3	13.4	6.3	9.7	12.9	21.0^{b}	28.9^{c}	35.0^{b}	50.6^{b}	76.1^{b}	82.4^{b}	89.7^{b}	96.7^{b}	98.6^{b}	101.5^{b}	106.5^{b}	113.4^{b}
ANOVA	ns	ns	ns	ns	**	**	**	**	**	**	**	**	**	*	*	*
LSD	-	-	-	-	2.53	3.07	7.42	22.80	22.42	21.76	22.16	21.42	32.12	30.20	26.57	26.15

**Treatment means in the table share the same letter superscript indicate no significant difference, based on the LSD test at a 1% probability level.
*Treatment means in the table share the same letter superscript indicate no significant difference, based on the LSD test at a 5% probability level.

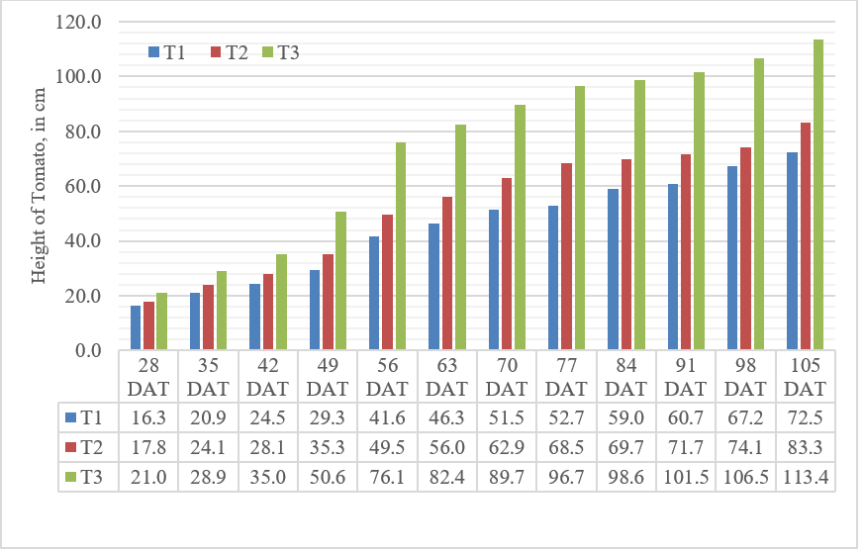


Chart 1: **Weekly heights (in cm) of tomato from 28 DAT to 105 DAT as affected by magnetically treated water**

3.2 Yield Parameters

The average number of tomato flowers and fruits and the weight of harvested tomatoes (grams) are depicted in Table 2. The ANOVA showed no significant differences in the number of tomato flowers and fruits between treatments. This implies that the effects of magnetization on the number of tomato flowers and fruits using 6 and 12 magnets is comparable to the control; however, based on Table 2, there is an apparent trend in the relationship between the number of magnets and the two parameters which possibly mean that further increasing the number of magnets would entail for an increase in the number of tomato flowers and fruits.

In contrast, the impact of magnetically treated water might be observed in the later stages of fruit development, as it revealed a significant increase ($p < 0.05$) in the average weight of tomato fruits when irrigated with magnetized water using a magnetic device with 12 magnets (T_3) compared to 6 magnets (T_2) and the control (T_1), as shown in Table 2. Furthermore, an average of 7,830 g of harvested tomato fruits showed a 64.12% increase compared to 1,687 g of harvested tomato fruits not irrigated with

magnetically treated water. The results of this study demonstrated that the application of magnetic treatment to irrigation water significantly affected the vegetative growth of tomato plants and resulted in increased tomato yield. These effects of magnetically treated water on tomatoes are consistent with previous studies, like its productivity under salinity stress (Samarah et al., 2021)[8], a 61.7% increase in fruit fresh biomass (Ospina-Salazar et al., 2021)[9], increased in the production of commercial tomato fruits (Putti et al., 2024)[14] and an increase in its average weight, firmness, and the juice content of the fruits (Omari et al., 2022)[6].

Similar findings of Agcaoili (2019)[11] and Adorio et al. (2022)[15] on the fresh weight of lettuce and Galvan (2021)[11] on the fresh weight of pechay align with the current study, which found a positive impact on the use of magnetically treated irrigation. Earlier studies have shown that MW can help crops grow better in challenging situations like high salt levels or hydroponic systems. However, this is the first study to examine how it affects tomato yield in an aquaponics system. The results are promising, with a remarkable 64.12% increase in fruit weight and evidence that the number of magnets plays a role in the improvement of yield in crop production.

Table 2. The effect of using magnetically treated water on the number of flowers, number of fruits and weight of tomato fruits in aquaponics system

Treatment	Number of Tomato Flowers	Number of Tomato Fruits	Weight of Tomato Fruits, grams
T_1	476	401	1687[b]
T_2	907	779	3728[b]
T_3	1928	1795	7830[a]
ANOVA	ns	ns	*
LSD	-	-	1893

*Treatment means in the table share the same letter superscript indicate no significant difference, based on the LSD test at a 5% probability level

4 Conclusion

The findings and results of this study demonstrate the advantages of employing magnetically treated water used for irrigation in relation to tomato growth and yield parameters, such as height, the number of flowers and fruits, and fruit weight, in an aquaponics system. The magnetically treated water in the aquaponics system enhanced the plant's height and fruit weight. The highest plant height and harvest weight were achieved on tomatoes irrigated with magnetically treated water with twelve magnets. A 56.41% increase in plant height and a 64.12% increase in the weight of the fruits were attained using magnetic technology as irrigation water. These findings confirm the results of previous studies and provide new opportunities for improving aquaponics systems through innovative water treatment techniques.

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