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Magnetic Treatment of Irrigation Water and its Influence on Radish (*Raphanus sativus*) crop*:* A Green Technology

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ABSTRACT

Implementation of water treatment technologies for poor quality water may help reduce dependency on freshwater. One promising technology among water treatment technologies is magnetic water treatment (MWT). This study was aimed to evaluate the impact of bore water, hard water (1000 ppm) and saline water (electrical conductivity of 3 dS/m) on the plant biometric parameters and the yield of the radish. The water was treated in three stages: electrolysis, de-ionization and magnetization. In the pot culture experiment conducted, leaf length and leaf area index (LAI) was maximum under magnetized bore water treatment which was 22.7 cm and 6.2 compared to all other treatments respectively. The fresh weight (66.2 g) was highest in magnetically treated bore water, which was statistically significant over control. Among bore water treatments, the average yield per plant (48.5 t/ha) was maximum under magnetized bore water over control (43.9t/ha). Overall, the findings suggest that magnetically treated irrigation water positively influences plant growth parameters and the yield of radish.

Key words : *Poor quality water, Magnetic water, Electrolysis, De-ionization.*

Introduction

Freshwater scarcity is becoming more of an issue, particularly in Mediterranean countries and southern Asian countries like India. The Mediterranean countries are the most vulnerable to drought among Europe's countries. There is approximately 1351 million km^3 of water on Earth but only 3 per cent of that is usable freshwater for drinking and agriculture (Winpenny*et al.*, 2010). According to an FAO assessment, each person would have had access to 5000–6000 m^3 of freshwater per year in an ideal case where all accessible water on Earth was evenly divided to a uniformly dispersed population. It is predicted that climate change will account for about 20 per cent of the global expansion in water scarcity (FAO, 2012), and this would affect the development and functioning of communities worldwide, both in social and economic terms. According to specialists, humans feel water shortage below a threshold of 1700 m^3/person, therefore the ideal condition would have been for each individual to have access to plentiful fresh water supplies. Rising competition from other water-using industries and other factors concerns the environment (Surendran *et al.*, 2016). Water resources are continuously under pressure for various reasons and necessitate a systematic method to ensure agricultural crop productivity. One of the most significant limiting issues for crop output and food security is the growing shortage of freshwater

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resources.

Irrigation is the largest user of fresh water in agriculture, accounting for 70 per cent of total outflow. Agriculture in India and many other countries are suffering because of water quality issues and freshwater scarcity.The usage of low-quality irrigation water, such as high salinity, hardness, and wastewater, is becoming more critical in today's world. As a result, current agricultural efforts are increasingly focused on developing an efficient eco-friendly production method that will increase crop productivity while minimizing environmental impact.

One such area is magnetic water treatment technologyand magnetic field applications have been recognized for decades. In 1830, Michael Faraday proposed the notion of induction, saying that electrical current is induced when flow ions or a conductive medium crosses a magnetic field flux. Even though magnetic field applications were quickly pursued to confirm Faraday's assertion, there was still a lack of interest from researchers and industrialists around the world (Zaidi *et al.*, 2014). Magnetized water offers a wide range of uses in industry, agriculture, and medicine (Teixeira da Silva and Dobranszki, 2016). According to research done, water can be magnetized when exposed to a magnetic field (Pang and Deng, 2008). Seed germination percentages (Matwijczuk *et al.*, 2012), essential element uptake (Maheshwari and Grewal, 2009), and seed yield (Selim and El-Nady, 2011) have all been reported to benefit from magnetically treated irrigation water. However, there is hardly any study in concern with the magnetization of irrigation water treatment and its impact on the radish *(Raphanussativus)* crop. Hence, research was carried out to study the effect of magnetic water on biometric parameters and crop yield.

Materials and Methods

A series of experiments (Fig. 1) were conducted from March 2021 to August 2021 in the micro-irrigation park of ICAR-Central Institute of Agricultural Engineering, Bhopal (23^0 18' 35'' N and 77^0 24' 10'' Esituated 527 m above mean sea level (MSL). The experimental area's annual average rainfall is 1126.7 mm, with 75 per cent of it being received between July to September (Rao *et al.*, 2021). The plan comprised of pot culture experiment withradish as a test crop. There is practically no rain from December to March and the temperature gradually rises from October onwards, peaking in May, the hottest month of the year. The experiment was conducted in a Completely Randomized Design (CRD) with three replications. The plant biometric data such as leaf length, leaf area index (LAI) and yield were recorded at the final harvest in every replication. The data were tabulated and statistical analysis was accomplished in a full factorial in which each treatment was replicated three times. In this study, two different types of irrigation water were used: magnetic and non-magnetized (MW and Non-MW) bore

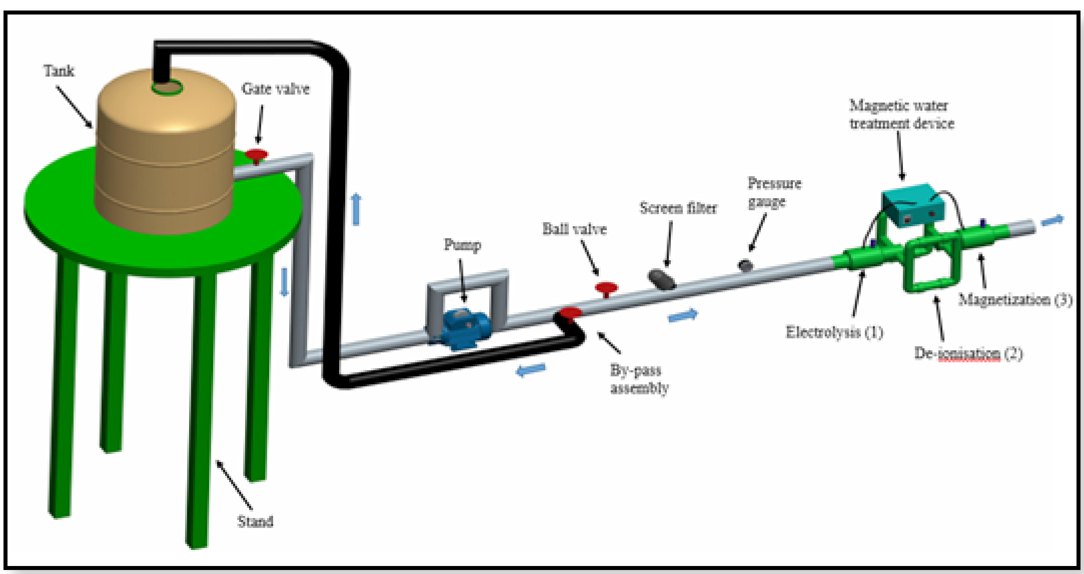

Fig. 1. Experimental layout of magnetic water treatment device set-up

water, hard water (1000 ppm) and saline water (EC= 3dS/m). The fruits were picked after reaching the harvesting stage and the overall yield was estimated. The analysis of variance (ANOVA) was used to determine the major effects of irrigation water types, magnetic treatment on plant growth parameters. The differences between pairs of treatment means were investigated at a 5 per cent level of significance by paired t-test (treatment vs control) in design expert software.

Results and Discussions

Leaf Length (cm)

The different treatments significantly influenced the leaf length which varied from 13.7 to 22.7 cm (Table 1). Among all the treatments analysed, magnetized bore water treatment had the highest leaf length followed by magnetized hard water treatment and this leaf length was found significantly higher than the other treatments. These findings could probably be explained on the basis that increasing the number of water molecules in a volume unit by passing it through a magnetic field enhanced the water molecules' ability to absorb nutrients(Teixeira and Dobranszki, 2014).

Table 1. Effect of magnetic water treatment on leaf length of radish (cm)

Solutions	Leaf Length (cm)		
	Magnetic treated	Control	p-value
Bore water	22.7	20.5	0.04*
Hard water, 1000ppm	20.7	18.6	0.05^{ns}
Saline water, EC= 3 dS/m	17.0	13.7	0.06^{ns}

Leaf Area Index (LAI)

LAI at the harvesting stage varied from 4.5 to 6.2. Magnetized bore water treatment had the highest proportion of LAI (Table 2). However, no significant difference was observed in hard water. These findings can be probably explained on the basis that the effects of magnetic fields on plant metabolism viz. photosynthesis, hormonal and enzymatic activities and movements of endogenous solutes, particularly carbohydrates and hormones moved from synthesis zones to the growth zone might be the reason (Ali *et al.,* 2014).

Table 2. Effect of magnetic water treatment on LAI

Solutions	LAI		
	Magnetic treated	Control	p-value
Bore water	6.2	5.9	0.03*
Hard water, 1000ppm	5.9	5.8	0.06^{ns}
Saline water, EC=3 dS/m	4.9	4.5	0.04*

Fresh weight of radish root per plant (g)

In the bore water treatments (Table 3), the magnetically treated solution of bore water produced a significantly higher yield (66.2 g/plant) as compared to the control treatment (60.9 g/plant). The current study's findings are comparable to those of (Belyavskaya, 2004), who found that magnetic fields boosted strawberry and tomato fruit production.

Table 3. Effect of magnetic water treatment on yield of radish (gm/plant)

Solutions	Radish root weight (gm)		
	Magnetic treated	Control	p-value
Bore water	66.2	60.9	0.03*
Hard water, 1000ppm	63.6	58.8	0.04*
Saline water, EC= 3 dS/m	52.8	50.0	0.06^{ns}

Total yield of radish (t/ha)

The data (Table 4) clearly showed that the total yields of radish per plant were found significant. In the bore water treatment s, the magnetically treated solution of bore water produced a significantly higher yield (48.5 t/ha) than the control treatment (43.9 t/ha). However, no significant difference was observed in hard water but a significant difference was also observed in saline water. Increased enzymatic activity, as well as water and nutrient molecular mobility, might have enhanced crop development and productivity(Vashisth and Nagarajan, 2010).

Table 4. Effect of magnetic water treatment on yield of radish (kg/plant)

Solutions	Yield (t/ha)		
	Magnetic treated	Control	p-value
Bore water	48.5	43.9	0.03*
Hard water, 1000ppm	44.8	41.1	0.06^{ns}
Saline water, EC= 3 dS/m	36.6	32.3	0.04*

Conclusion

Magnetized irrigation water positively affected the leaf length, LAI and yield of the radish. It can be interpreted from these results that magnetized water has a substantial impact on the radish. The variations in pH and EC caused by magnetically treated irrigation water resulted in increased biological activity in plants that influenced plant development. Magnetic water has increased productivity by reducing the molecular structure of water and increasing the efficiency with which fertilizers, nutrients and water are delivered to plants. Enzymes and hormones might have activated more quickly because of the high gradient magnetic field, resulting in better nutrient mobilization and transportation during the growth period.

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