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Effect of Magnetized Irrigation Water and Seeds on the Production of OKRA (*Hibiscus esculentus*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Very recently special magnetic devices have been developed and used to magnetize irrigation water and plant seeds. Such magnetic treatments were reported to play a great role in increasing the germination rate of seeds, reducing soil salinity and consequently resulting in increasing yield. The objectives of the study to improve crop productivity by using magnetic technologies. A split plot experimental design was used for growing two varieties of okra (*Hibiscus esculentus*). The treatments included: non-magnetized water + non magnetized seeds (NMW+NMS), non-magnetized water + magnetized seeds (NMW+MS), magnetized water + non magnetized seeds (MW+NMS), magnetized water + magnetized seeds (MW+MS). Each treatment was replicated three times. The parameters considered included: number of leaves per plant, leaf length, plant height, plants density and yield. There was a significant difference ($p < 0.05$) between treatments,

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the combination of (MW) and (MS) gave higher of leaves per plant, plant density, and plant height and leaf length. There was a significant difference ($p < 0.05$) in yield between treatments (MW) recorded increasing in yield by 50% as compared to (NMW); (MW) + (MS) recorded increase in yield by 24% as compared to (NMW); (MS) record increasing in yield by 18% as compared to (NMS) when both were irrigated by (NMW), the combination of (MW) and (MS) gave higher yields for both okra varieties (25.5 and 35.5 Kg/ha). It was concluded that magnetizing water may lead to better crop establishment and further improvement could be achieved by magnetizing the seeds.

Keywords: Magnetic devices; magnetic technologies; magnetizing water; crop productivity; okra.

1. INTRODUCTION

"Irrigation has often been defined as the method of applying water to the soil to supplement that from rainfall for maximizing production per unit area. Irrigated agriculture is the largest consumer of water in the world. In areas with dry climate, irrigation water amount to 50-85% of total water use" [1]. The growing scarcity and misuse of the available water resources, particularly in arid and semi-arid regions, constitute challenges to water demands for various utilities.

"Sudan is envisaged to face water shortage very soon. Utilization of water from the river Nile and its tributaries is abided by international agreements with neighboring countries. Rainfalls are unpredictable and evaporation losses are high under such arid conditions. Agriculture in Sudan is either irrigated or rain-fed. Irrigated agriculture depends mainly on water from the river Nile and its tributaries. The utilization of the Nile water is controlled by the 1959 Nile water agreement with Egypt" [2].

"The use of magnetic devices for magnetizing irrigation water started in the 1960s, after which increased attention has been paid to develop efficient and sustainable utilization methods" [3,4]. "Magnetization causes physical and chemical changes of natural water characteristics, resulting in an improvement of its infiltration rate and an increase in its dissolving properties. These changes result in an increased ability of soil to get rid of salts which would consequently result in a better assimilation of nutrients and fertilizers in plants during their growing cycles. Magnetic water is obtained by passing water through permanent magnets or through the electromagnets installed in or on a feed pipeline" [5]. "Plants need mineral salts and trace elements from the soil for healthy growth and maximum yield. The mechanism of magnetization of water and proposed a theory based on the molecular structure of water" [6]. "{Minerals and nutrients must be well balanced in the soil at an appropriate pH level in order to be fully utilized by the plants" [7], magnetized technology has great benefits for soil improvement and plant growth [5]; (Ahmed and Bassem, 2013).

"Watering plants with magnetized water dissolves more nutrients because it lowers the surface tension of water. This lets more minerals be suspended in concentration. This buffers the pH and causes more minerals and nutrients to pass through the cell walls of plant roots. Magnetized water penetrates the soil faster and deeper, allowing roots to penetrate and grow larger. In addition, the changes caused by the magnetic influence depend on many factors, such as strength of the magnetic field, direction of applied magnetized field, duration of magnetic exposure, flow rate of the solution, additives present in the system, and the pH" [5,8-12]. "Magnetized water dissolves more nutrients within the root zone and becomes readily available to be taken up by the roots and hence stimulates plant growth and increase water-use efficiency (WUE) and crop yields" [13]. "These may be the reasons why plant growth rates are increased. Crop yields are higher in a shorter period of time, and with much less need for water, fertilizers and pesticides. This is the reason why magnetized water is recommended for irrigation. These results in increased good quality, crop production coupled with savings in cost and reduction in environmental hazards. It has been found that magnetized water treatment can promote seed germination, crop growth, increase yield, and improve fruit quality" [14,15]. Haq et al. [16], Gholami and Sharafi [17] reported that the Magnetic seed treatment enhanced seed germination, seedling growth, fresh and dry weight, activities of some enzymes and seed yield in wheat.

On the other hand, Iqbal et al. [18] obtained that the magnetic field exhibited increased germination of pea seeds. Shahin et al. [19] concluded that "magnetic treatment of irrigation water plays an important role for growth parameters of cucumber plant. Magnetic irrigation water and or magnetized seeds showed significant increase in germination percentage of tomato, eggplant, squash and cucumber".

This study has been conducted with a view to evaluate the effect of magnetizing irrigation water and /or seeds on crop production under Sudan condition, okra *Hibiscus esculentus*, have been taken as an indicator plant.

2. MATERIALS AND METHODS

The experiment was conducted in the Demonstration Farm of the faculty of Agriculture, University of Khartoum, Shambat which lies at 15° 40' N latitude and 32° 32' E longitude.

"The study was carried out during summer season of 2020. The experimental period extended from April to July. The climate of the area is tropical semi-arid, characterized by low relative humidity with mean daily maximum and minimum temperatures of about 36°C and 21°C respectively. The annual rainfall is about 158 mm mainly during July, August and September" (Sudan Meteorological Department 1951-1980). During the experimental period of April – June, no rainfall was recorded.

"The soil in the experimental field is heavy clay with percentages ranging between 65% in the top 15 cm and 55% in the 100-140 cm depth. The soil reaction is moderately alkaline with a pH ranging from 7 to 8" [20]. The infiltration rate is low and has been estimated to be about 20 mm/hr in the first two hours and 5 mm/hr after 10 hours [21].

An area of 170 m^2 was divided into two sections and planted with two varieties of okra Madni and Kosti (Need to mention the source). One section was irrigated with magnetized water. The treatments were arranged in a split-plot design, and each treatment was replicated three times giving a total of 12 plots. The seeds were magnetized either on the dry and when they were soaked in water.

2.1 Magnetization Processes

A magnetic funnel and a container were used to soak seeds in; magnetic field of strength 3000 Gauss, the required amount of water was poured to pass through the magnetic funnel into the container; the seeds were then passed through the magnetic funnel into the container with magnetized water. The seeds were left in the magnetized water for about 30 minutes and then the water was poured out of the container and the seeds were passed through the magnetic funnel again, and were ready for sowing according to Aladjadjiyan [22].

Magnetization of the dry seeds was done simply by passing the seeds dry through a magnetic funnel.

2.2 Land Preparation

The experimental field was ploughed with a standard integral mounted disc plough at a depth of about 0.25 m. The land was then left for two weeks then leveled with a general-purpose blade. Ridging was done at a spacing of 0.7 m with a general-purpose ridge.

Fig. 1. Magnetic Funnel and seed magnetization

2.3 Planting

Okra seeds were sown on 28th April 2020 at a seed rate of about 8 Kg per feddan. Two to three seeds were planted manually in rows on the eastern side of the ridge at a spacing of 30 cm between plants.

2.4 Irrigation System

The experiment was cured out under furrows irradiation system, water source from domestic water supply system with centrifugal pump of 2 hp capacity.

2.5 Data Collection

The plant growth parameters measured were as follows:

a) **Number of leaves per plant:** Nine plants were taken at random from each three ridges and the mean number of leaves per plant was recorded.
b) **Density of plant:** Number of plants for each three ridges was counted then the mean density was recorded as number of plants per unit area.
c) **Plant height:** Eight weeks from sowing, plants height was measured by a wooden ruler from the base of the stem to the tip of youngest leaf. Nine plants were taken at random from each three ridges, their mean height was recorded.
d) **Length of leaves:** Nine plants were randomly selected from each three ridges, and the mean length of the leaves was recorded.
e) **The yield:** A sensitive balance was used to weigh the end product.

3. RESULTS AND DISCUSSION

The experimental results are presented in the tabular form of Tables 1 & 2 they exhibit the following information:

3.1 Number of Leaves per Plant

Table 1 shows that there was no significant difference $p < 0.05$ in the number of leaves per plant when either or both MW + MS, but a significant difference is indicated when neither one of them was magnetized NMW + NMS.

Both okra varieties Kosti and Madani gave higher values for number of leaves per plant when both water and seeds were magnetized MW+MS, they were respectively 17.23 and 12.7 leaves /plant Table 2. These findings were in agreement with Ziaf et al. [23].

3.2 Plant Density

Table 1 shows a significant difference $p < 0.05$ when either or both water and seeds were magnetized MW + MS as compared to when neither one of them was magnetized. The combination of magnetized water and magnetized seeds gave higher plant density per m^2 for both okra varieties; they are 14.9 plants /m for Kosti and 13.87Plants/m^2 for Madani (Table 2). these findings were agreed with Nyakane et al. [24] and Ziaf et al. [23].

3.3 Plant Height

With respect to plant height, there was no significant difference when either water or seeds were magnetized. Furthermore, it was found that both okra varieties Kosti and Madani gave higher values of plant height for the combination of magnetized water and magnetized seeds; they are 59 cm for Kosti and 57.1 cm for Madani (Table 2).

3.4 Leaf Length

A significant difference $p < 0.05$ in leaf length was obtained from magnetized water 8.05 cm as compared to 6.15 cm when non magnetized water was used (Table 1). It was found that when magnetized water was used there was no significant difference $p < 0.05$ in the leaf length whether the seeds were magnetized or not magnetized (Table 1).

Referring to Table 1 it was noticeable that when non magnetized water was used there was a significant difference $p < 0.05$ in the leaf length of magnetized seeds (8.0 cm) as compared to non-magnetized seeds (6.15 cm).

The combination of magnetized water and magnetized seeds gave higher averages of leaf length for both okra varieties, they are 9.2 cm for Kosti and 8.9 cm for Madani (Table 2).

3.5 Yield

There was a significant difference $p < 0.05$ in yield when okra was irrigated by magnetized water (14.8 Kg/ha) as compared to non-magnetized water (7.4 Kg/ha).

Table 1. Analysis of the effects of magnetized and non-magnetized water and seeds on some agronomic parameters of okra crop

	Magnetized water		Non magnetized water		
Parameters	**Mag. seed**	**Non mag. seeds**	**Mag. seeds**	**Non mag.seeds**	**LSD**
Number of leaves/plants	a 12.12	a 12.12	a 14.97	a 7.85	a 2.88
Plant density (plants/m2)	a 12.8	ab 11.45	ab 11.45	b 8.0	3.70
Plant height (cm)	a 48.45	a 45.77	a 43.33	a 39.55	12.07
Leaf length (cm)	a 9.05	a 8.05	a 8.0	b 6.15	1.49
Yield (Kg/ha)	a 19.4	b 14.8	c 9.0	d 7.4	1.38

Table 2. Mean comparison test

Magnetized water				Non magnetized water				
Kosti		Madani		Kosti		Madani		
Mag. Seeds	**Non mag. seed**	**Mag. Seeds**	**Non mag. seed**	**Mag. Seeds**	**Non mag. seed**	**Mag. Seeds**	**Non mag. seed**	**LSD**
a 17.23	bc 12.43	bc 12.7	de 9.9	b 14.33	ef 8.9	cd 11.8	f 6.8	2.14
a 14.9	b 8.0	a 13.87	b 9.1	a 13.6	b 8.0	a 12.0	b 8.0	2.75
a 59	a 37.9	ab 57.1	cd 39.8	ab 53.63	bc 47.9	de 31.2	e 27.67	8.97
a 9.2	bc 7.8	Ab 8.9	C 7.1	Ab 8.9	C 9.6	Ab 8.3	d 5.4	1.11
b 25.5	e 4.3	a 35.5	c 13.9	e 4.2	f 2.5	d 10.6	ef 3.4	1.02

A significant difference $p < 0.05$ was also obtained with combinations of magnetized water and magnetized seeds 19.4 Kg/ha as compared to a combination of magnetized water and non-magnetized seeds 14.8 Kg/ha (Table 1).

Table 1 also shows a significant difference in the yield of magnetized seeds (9.0 Kg/ha) as compared to non-magnetized seeds while it was 7.4 Kg/ha when both were irrigated by non-magnetized water was used. The combination of magnetized water and magnetized seeds gave higher yields for both okra varieties, namely 25.5 Kg/ha for Kosti and 35.5 Kg/ha for Madani (Table 2), these results are in agreementwith Alwan et al. [25] and Nyakane et al. [24] who reported that, using proper combination of magnetic field intensity and time of exposure is a fundamental key to consider in other to enhance the crop productivity and development.

4. CONCLUSION AND RECOMMENDATIONS

From the results of this study the following conclusion and recommendations can be drawn:

- Magnetizing irrigation water can lead to better crop production and further improvement may be attained by magnetizing the seeds.
- The major problem associated with magnetization technology may be the high initial cost for the device and its requirement for special conveyance accessories.
- Since the technology of magnetization has been newly introduced in Sudan and proven to have good potential in agricultural production, further research studies are highly recommended in this area.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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