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# Effect of Magnetized Water on the Germination and some Yield Components of Swiss Chard (Beta Vulgaris Var. Cicla )

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**Abstract:- A pot experiment was conducted at Faculty of Education, Alzaeim Alazhari University, Khartoum, Sudan to evaluate the effect of magnetized water on Swiss chard plant for two successive seasons (2016-2017). The results showed a significant difference in the germination, shoot length, leaf area, shoot fresh and dry weight and root fresh and dry weight. The results also showed a significant difference in chlorophyll content [chlorophyll a, b and a+b]. The results of the study indicated an increase in some chemical elements (N, K, P and Ca) for plants irrigated by magnetized water compared with plants irrigated with untreated water.**

***Keywords:-*** *Magnetized water, yield components, chemical elements, Swiss chard.*

## I. INTRODUCTION

The new trend of modern agriculture to more sustainable ways of agriculture, has led the investigation of some more environmental friendly techniques. These techniques should have a low environmental impact, and at the same time to contribute for the increase of yield in crops. Over many years, the effects of static magnetic fields on plant have been the subject of a different research studies (Hirota et al., 1999). Exposure of seeds and water to electromagnetic fields is one of the safe and affordable potential physical treatments to enhance post germination, plant development and crop stand (Florez et al., 2007). Magnetic field affected the various characteristics of the plant like germination of seeds, rate of seedling growth, root growth (Reina et al., 2007). The present work was carried out to study the response of some growth characteristics of Swiss chard plant to the irrigation of magnetized water.

## II. MATERIAL AND METHODS

The chard plant seeds were local cultivar, obtained from the local market.

## III. MAGNETIC DEVICE

A magnetic funnel (Magnetic Technologies L.L.C. Model No. MFLa, Dubai, U.A.E.) was used for water treatment.

## IV. LABORATORY EXPERIMENT

The seeds of chard plant with uniform size, without seen defect or insect damage were arranged to four treatments as the following:

- The first treatment, seed were irrigated with tap water (the control).
- The second treatment, seeds were irrigated with magnetized water (once).
- The third treatment, seeds were irrigated with magnetized water (three times).
- The fourth treatment, seeds irrigated with magnetized water (four times).

The germination tests were carried out at laboratory conditions. Seeds of chard plant were germinated in sterilized Petri dishes, 100mm on diameter, on Whitman filter paper moistened with 10ml of double-distilled water. Petri dishes were kept in the dark, at 25ºC, for a span of 7 days. During the experiment germinated seeds were counted daily and then the percentages were calculated at the end of the experiment. During the experiment water was added according to the necessity.

## V. POT EXPERIMENT

Soil material: the soil used in all treatments in experiment was silt soil.

## VI. SEEDS GERMINATION

Plastic pots (35cm in diameter and 36cm in depth) were arranged in a completely randomized design. Each pot contained a silt soil. There were three replications per each treatment. Seeds were sown in a uniform depth of 20mm and five seeds per pot. Measured volume (600ml/pot) of water with or without magnetic treatment was applied in each pot soon after sowing according to the treatments described earlier and then daily during the entire duration of the experiment. The number of seedlings emerged were counted daily for each treatment during the study. At harvest, seedling shoots were separated from roots and the harvested seedlings were weighted for fresh weight and then dried in an oven at 65.8ºC for 48 hours for the dry weight. The dried seedlings were then analyzed for nutrient concentration. Part of the dried shoot of chard plant were digested in nitric acid and used for determination of P, K, Mg, Ca. Determination of chlorophyll content was estimated according to the Arnon (1949).

All data relating plant height, number of leaves, leaf area, stem diameter, fresh and dry weight of shoot and root were tabulated and statistical analyzed using analysis of variance (ANOVA) according to Gomez and Gomez (1984).

## VII. RESULTS AND DISCUSSION

*A. Laboratory experiment*

The data in Table (1) showed significant increase (P=0.05) in the germination of chard plant in the two seasons 2016 and 2017. The highest germination percentage was obtained by treatment four $T_4$ (36.66%) and treatment three $T_3$ (48.66%) in the season 2016 and 2017 respectively. Many works have been reported to exert a positive effect of magnetic field on the germination of seeds, plant growth and development and yield of field crops (De Souza et al., 2006; Shabrangi and Majd, 2009). The results of the study are supported by the findings of Hilal and Hilal (2000) who reported that improvement in germination and seedling emergence of tomatoes, pepper, cucumber and wheat when magnetically treated water and seeds were used, and the results of Morejon et al. (2007) who observed an increase in germination of Pinus tropicalis seeds with magnetically treated water.

The irrigation with magnetically treated water and seed absorption of magnetized water before sowing may be responsible for activation of enzymes and hormones involved in the germination process and mobilization of nutrients. As a result, there is probably an enhancement in the mobilization and transportation of nutrients to embryonic axis and a resultant increase in speed of emergence and germination rate.

*B. Pot experiment*

Table (2) indicated that the plant height of chard plant was significantly increased ten days after sowing (10 DAS) in both seasons 2016 and 2017. Also significant difference (P=0.05) was observed at (20 DAS) and at (30 DAS) in both seasons experiment. In this respect Aladjadjiyan (2002) showed that exposure of Zea *mays* seeds to magnetic water has a favorable effect on the development of shoots in the

| Treatment | Germination percentage | |
|---|---|---|
| | 2016 | 2017 |
| $T_1$ | 20.33 | 26.66 |
| $T_2$ | 34.66 | 40.33 |
| $T_3$ | 35.0 | 48.66 |
| $T_4$ | 36.66 | 41.00 |
| LSD | 13.02 | 11.9 |

Table 1. Effect of magnetized water on germination of chard plant in the year 2016 and 2017

| | Treatment | Plant height (cm) | | |
|---|---|---|---|---|
| | | 10DAS | 20DAS | 30DAS |
| 2016 | $T_1$ | 4.73 | 5.70 | 6.23 |
| | $T_2$ | 5.60 | 8.88 | 9.80 |
| | $T_3$ | 6.53 | 8.18 | 9.91 |
| | $T_4$ | 6.40 | 8.63 | 10.00 |
| | LSD | 0.86 | 1.42 | 1.33 |
| 2017 | $T_1$ | 4.60 | 5.62 | 5.90 |
| | $T_2$ | 5.96 | 7.88 | 8.93 |
| | $T_3$ | 6.23 | 8.03 | 10.03 |
| | $T_4$ | 6.46 | 7.96 | 9.43 |
| | LSD | 0.80 | 1.11 | 1.00 |

Table 2. Effect of magnetized water on plant height of chard in the years 2016 and 2017.

early, stage. Atak et al. (2003) concluded that magnetic field increased the shoot and root regeneration rate in soy bean. Moreover, Celik et al. (2008) concluded that magnetized water increased growth and consider an important factor for inducing plant growth. Also Abdul Qados and Hozayn (2010) reported that irrigation flax with magnetized water increased plant height and Mohmood and Usman (2014) reported that an increase in plant height, seedling weight of maize were noted with magnetized water, and they concluded that, the increase in seedling height and weight may be due to earlier emergence of maize seedling irrigated with magnetized water in contrast to the control. These results may be attributed to the role of magnetic treatment in increasing absorption and assimilation of nutrients consequently increasing plant growth.

Table (3) showed the number of leaves per plant as influenced by magnetized water in the two seasons 2016 and 2017. The statistical analysis showed a non-significant effect in number of leaves between treatments in both seasons experiment except at 30 DAS in the first season experiment (2016).

Table (4) clear out that irrigation chard plant with magnetized water increased the leaf area in both seasons (2016 and 2017). These results concur with the results of Naz et al. (2012) who found an increment in leaf area of okra treated with magnetic field compared to controls, and the results of Deshpande (2014) who found an increase in leaves area and plant height of beans and peas when irrigated with magnetic water. The increment in leaf area might be due to increased photosynthetic rates due to greater interception of light (Racuciu et al., 2006; Vshisth and Nagarjan, 2010).

The shoot fresh weight expressed a significant increase in the first and second season 2016 and 2017 (Table 5). These results are supported by the findings of Fisher et al. (2004) who reported that sunflower seedling exposed to vertical magnetic fields showed a small but significant increase in total fresh weight, shoot fresh weight and root fresh weight, while

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the dry weight and germination rates remained unaffected. The root length showed a significant increase where chard plant irrigated with magnetized water in the two seasons 2016 and 2017 (Table 6). These results are correspondence with the results of Morejon et al. (2007) and the results of Vashisth and Nagarajan (2008) who found an increase in chick pea seedling vigour, improvement seedling root length and an increase in seedling dry weight. They suggested that there may be resonance – like phenomena which increase the internal energy of the seed and therefore it may be possible to get higher yield.

| | Treatment | Number of leaves (cm) | | |
|---|---|---|---|---|
| | | 10DAS | 20DAS | 30DAS |
| 2016 | $T_1$ | 3.86 | 4.20 | 4.53 |
| | $T_2$ | 4.43 | 4.73 | 4.93 |
| | $T_3$ | 4.06 | 4.50 | 4.66 |
| | $T_4$ | 4.50 | 4.80 | 5.02 |
| | LSD | NS | NS | 0.27 |
| 2017 | $T_1$ | 4.20 | 4.60 | 4.93 |
| | $T_2$ | 4.70 | 5.06 | 5.26 |
| | $T_3$ | 4.46 | 4.80 | 5.06 |
| | $T_4$ | 4.50 | 5.03 | 5.23 |
| | LSD | NS | NS | NS |

Table 3. Effect of magnetized water on number of leaves of chard plant in years 2016 and 2017.

| | Treatment | Leaf area (cm) | | |
|---|---|---|---|---|
| | | 10DAS | 20DAS | 30DAS |
| 2016 | $T_1$ | 4.03 | 8.05 | 8.86 |
| | $T_2$ | 11.26 | 12.64 | 15.72 |
| | $T_3$ | 11.36 | 12.64 | 13.47 |
| | $T_4$ | 10.51 | 11.51 | 12.00 |
| | LSD | 4.84 | 3.09 | 3.34 |
| 2017 | $T_1$ | 3.76 | 4.50 | 5.03 |
| | $T_2$ | 9.13 | 8.3 | 8.00 |
| | $T_3$ | 8.90 | 7.51 | 8.16 |
| | $T_4$ | 76.00 | 72.00 | 7.26 |
| | LSD | 4.61 | 2.53 | 1.57 |

Table 4. Effect of magnetized water on leaf area of chard plan in the years 2016 and 2017

| Treatment | Shoot length (cm) | |
|---|---|---|
| | 2016 | 2017 |
| $T_1$ | 13.75 | 9.41 |
| $T_2$ | 16.33 | 12.46 |
| $T_3$ | 16.00 | 12.33 |
| $T_4$ | 15.78 | 10.44 |
| LSD | 1.80 | 1.11 |

Table 5. Effect of magnetized water on number of shoot length of chard plant at harvest in year 2016 and 2017

| | Treatment | Shoot fresh weight (g) | Shoot dry weight (g) |
|---|---|---|---|
| 2016 | $T_1$ | 1.80 | 0.43 |
| | $T_2$ | 5.41 | 1.26 |
| | $T_3$ | 5.65 | 1.29 |
| | $T_4$ | 5.51 | 1.12 |
| | LSD | 1.31 | NS |
| 2017 | $T_1$ | 0.14 | 0.025 |
| | $T_2$ | 1.28 | 0.112 |
| | $T_3$ | 0.84 | 0.196 |
| | $T_4$ | 1.12 | 0.218 |
| | LSD | 0.50 | NS |

Table 6. Effect of magnetized water on shoot fresh and dry weight of chard in plant at harvest in the years 2016 and 2017

Table (7) indicated a significant difference (P=0.05) between treatments in root fresh and dry weight in the first season 2016. The highest root fresh weight (0.143g) was recorded in treatment $T_2$ and the lowest value (0.093g) at treatment $T_4$. On the other hand the root dry weight also showed significant difference between treatments with the highest value (0.47g) at $T_4$ and the lowest (0.012g) at the control. In connection to this, also the results of Grewal and Maheshwari (2010) who found an increase in root dry weight of chick pea and snow pea irrigated with magnetic water and the results Hozayn *et al*. (2013) who reported that an increase in root weight in sugar beet irrigated with magnetized water compared with non magnetized water.

The chlorophyll content of chard plant as indicated in Table (8) exhibited a significant difference (P=0.05) between treatment with the highest content of chlorophyll a (716.5) recorded at treatment $T_2$, chlorophyll b (270.8) at treatment $T_2$ and the total chlorophyll (a+b) recorded the highest value (987.3) at treatment $T_2$. In this respect, Tian et al. (1991) and Atak et al. (2000) concluded that, chlorophyll content of paulowinia was increased in plants exposed to magnetic field. The results of this study are confirmed by the results of Mihaela et al. (2009) who showed an increase in chlorophyll and carotenoids content specifically appeared after treatment with magnetic water and the results of Abdul Qados and Hozayn (2010) who reported that the magnetized water significantly increased chlorophyll a, b and chlorophyll a+b in lentil plant. In addition Moussa (2011) reported that, irrigation with magnetic water exhibited marked significant increase in the photosynthetic pigments (chlorophyll a, chlorophyll b and carotonoids), photosynthetic activity and translocation efficiency of the photo assimilates of common bean over the control. Also the work of Ahamed et al. (2013) who observed that sweet pepper (Capsiaum annum L.) leaf contents of chlorophyll a and chlorophyll b, carotenoids and phosphorus were significantly affected by the magnetic field.

| Treatment | Root length (cm) | |
|---|---|---|
| | 2016 | 2017 |
| $T_1$ | 6.06 | 2.80 |
| $T_2$ | 10.39 | 5.78 |
| $T_3$ | 10.06 | 6.31 |
| $T_4$ | 9.83 | 6.19 |
| LSD | 2.39 | 1.15 |

Table 7. Effect of magnetized water on number of root length of chard plant at harvest in the years 2016 and 2017

| | Treatment | Root fresh weight (g) | Root dry weight (g) |
|---|---|---|---|
| 2016 | $T_1$ | 0.040 | 0.012 |
| | $T_2$ | 0.143 | 0.040 |
| | $T_3$ | 0.106 | 0.043 |
| | $T_4$ | 0.093 | 0.047 |
| | LSD | 0.024 | 0.024 |
| 2017 | $T_1$ | 0.047 | 0.0036 |
| | $T_2$ | 0.097 | 0.026 |
| | $T_3$ | 0.086 | 0.026 |
| | $T_4$ | 0.076 | 0.023 |
| | LSD | 0.036 | 0.000 |

Table 8. Effect of magnetized water on root fresh and dry weight of chard in plant at harvest in the years 2016 and 2017

| Treatment | Chlorophyll (a) | Chlorophyll (b) | Total (a+b) |
|---|---|---|---|
| $T_1$ | 539.5 | 239.3 | 778.8 |
| $T_2$ | 716.5 | 270.8 | 987.3 |
| $T_3$ | 542.4 | 241.5 | 783.9 |
| $T_4$ | 597.5 | 241.6 | 838.1 |
| LSD | 1.048 | 0.553 | 0.109 |

Table 9. Effect of magnetized water on chlorophyll content (a, b and a+b) of chard plant

The chemical analysis of chard plant showed an increase in some element contents of chard plant (Table 9). The highest value of calcium concentration (7.503%) was measured at treatment $T_2$ and the lowest value (0.800%) at the control. Plant processes such as growth, photosynthesis, mineral nutrition, water transport are quite related to the motion of $Ca^{++}$ ion in cells, changes in intercellular levels of $Ca^{++}$ and other ionic current density across cellular membrane are important change which are due to magnetic fields (Florez et al., 2007). Concerning magnesium, the highest value (2.9497%) was observed at treatment $T_2$ and the lowest value (1.2000) was found at the control. Magnesium ions are found in the centre of chlorophyll molecules, and as chlorophyll is an essential component in the reaction of photosynthesis, which produces energy for growth magnesium ions are therefore essential (Bohn et al., 2004). The highest value of sodium (3.9718%) was observed in treatment $T_2$ and the lowest value (0.0277) was found at the control. In this respect Al-Khazan et al. (2011) reported that the accumulation of sodium content in plants treated with magnetized water was remarkable with high amount of sodium. In regard to nitrogen percentage, the highest value (1.951%) was recorded by treatment $T_4$ and the lowest value (0.055%) was observed at the control. In this respect Grewal and Maheshwari (2010) reported that a significant increase was observed using magnetic water in N, K, Ca, Mg, S, Zn, Fe and Mn in chickpea and snow pea and the results of Maheshwari and Grewal (2009) who found an increase in concentration of N, K, Ca, Mg, Fe, Mn and Zn of strawberry leaves exposed to magnetic field compared with the control.

Table (10) indicated an increase in potassium content with the highest value (226.88ppm) at treatment $T_2$ and the lowest value (15.16ppm) at the control. These results are in agreement with the results of Wojcik (1995) who reported that the contents of some elements in buck wheat grain (Mg, Fe, Cu) and straw (P, Ca, K, Zn) was greater in seeds exposed to magnetic field, the results of Grewal and Maheshwari (2011), and the results of Moussa (2011) who demonstrated that, there is a direct effect of potassium upon translocation efficiency, because potassium ion is known to be one of the three largest constituents in sieve tube sap. Concerning phosphorus, the highest value (4.20ppm) was observed at treatment $T_4$, while the lowest value (3.50ppm) was found at the control. These results agreed with the results obtained by Hilal et al. (2002) who reported that a marked increase in phosphorus content of citrus leaves irrigated by magnetically treated water. Also Al-Khazan et al. (2011) observed an increase in phosphorus content in jojoba (Simmondsia cinesis L.) treated with magnetic water. In addition, Bilalis et al (2013) found a significant increase in phosphorus percentage in cotton treated with magnetized water compared to the untreated plants.

| Treatment | Ca (%) | Mg (%) | Na (%) | N% | K (ppm) | P (ppm) |
|---|---|---|---|---|---|---|
| $T_1$ | 0.8000 | 1.1000 | 0.0277 | 0.955 | 15.16 | 3.50 |
| $T_2$ | 7.5037 | 2.9497 | 3.9718 | 1.010 | 226.88 | 4.10 |
| $T_3$ | 5.9138 | 1.7741 | 3.6592 | 1.033 | 141.88 | 3.90 |
| $T_4$ | 4.3359 | 1.3573 | 2.1208 | 1.951 | 168.80 | 4.20 |
| LSD | 0.000 | 0.103 | 0.000 | 0.000 | 0.000 | 4.20 |

Table 10. Effect of magnetized water on some chemical elements of chart and plant.

## VIII. CONCLUSION

Results of this study revealed beneficial effects of magnetized water for chard seed germination, significant increase in plant growth as well as the chlorophyll content and Ca, Mg, Na, N, P, K percentage. The magnetized irrigation water resulted in significant increase in the yield of chard.

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