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# Magnetic Technology for Mitigation Salinity Water Stress on Faba Bean (*Vicia Faba* L) Growing in Sandy Soil

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**Abstract**

To alleviation salinity stress on germination, growth, photosynthetic pigments, yield and yield components of faba bean; Laboratory using Faba bean (*Vicia faba* L; Var Nuberia-1) was conducted at Laboratory of Seed Technology Research Department, Field Crops Research Institute, Agriculture Research Canter, Giza, Egypt. As well as Field Experiments were conducted at Experimental Research and Production Station belonged to NRC at El-Emam Malak Village, El-Nuberia Region, El-Beheira Governorate, Egypt during three winter seasons of 2019-2022. Results of Laboratory experiment indicated that significant increases were recorded under application of magneto-priming seed treatment (0.26-28 Tesla) compared to untreated on Germination Index (GI), Seed Germination (G; %), Seed Germination Index (SGI), Germination Energy (GE; %) and Germination Rate (GR; day), root and seedling length (cm), root and seedling dry weight (g), seedling vigor-I and vigor-II of faba bean. The improvement reached 8.82, 8.82, 13.51, 6.87, 21.26, 31.34, 23.09, 21.33, 33.33, 22.99, 34.05 and 33.87% in the above-mentioned characters, respectively compared to untreated seed. Similar positive effect was observed in Mean Germination Time (MGT; day) where the seeds were faster germinated by 5.56% compared to untreated treatment. Under field conditions, irrigation with water passed through magnetic unit (2 inch, 0.26-28 Tesla and produced by NRC) induced positive significant effects on faba bean growth, total chlorophyll, some macro and micro-elements in leaves at 75 days after sowing, yield components, yield (ton $fed^{-1}$) and nutritional value of yielded seeds at harvest under sprinkler and drip irrigation systems. The percentage of improvement over both irrigation systems reached 10.90 – 22.28, 10.15, 4.99-21.218, 5.56-11.73% in the above-mentioned parameters, respectively. Under conditions of experiments, could be concluded that sowing magneto-priming seeds of faba bean and irrigation with magnetized water could alleviate salinity water stress which resulted in improvement of growth and productivity of faba bean under Nuberia region.

***Keywords:*** Faba bean; Magneto-priming seeds; Magnetized saline water; Germination; Growth; Seeds nutritional; Yield.

## 1. Introduction

Faba bean (*Vicia faba*, L.) is an important grain legume grown in tropical and subtropical region. It is a substantial crop belonged to family *Fabaceae* that supplying protein, vitamins and minerals. Because of its superior ability to fix atmospheric nitrogen, the faba bean is used as a good alternative source of animal proteins in human diets, as well as forage and fodder crop for livestock **[1].** Additionally, a ravishing product consumed in huge quantities in

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developing countries such as Central America, China, Egypt, Ethiopia and Turkey because of its cheap, easy transported and long storage life **[2].**

A fundamental concern in agriculture is salinity, which is considered a prime portion of the abiotic stresses in arid and semi-arid regions and it influences the agricultural land area in the world **[3].** However, implementation of elevated saline water has numerous adverse impacts on soil features, plant growth and productivity. Some studies suggested that usage of magnetized water (MW) in irrigation systems enhances soil features and minimize salinity and drought stresses on plants **[4].**

Globally, the climate alteration as well as increased population induced significant depletion of freshwater particularly in arid and semi-arid areas. **Hozayn *et al*., 2022[5]** mentioned that magnetization of saline water prior to irrigation may aid in mitigating the adverse impacts of salinity on crop productivity. Where many studies, reported that magnetization improves water merits via enhancing ability to permeate root cells, diminishing water viscosity, molecules' interaction, and breaking hydrogen bonds which initiate water absorption in roots and elevated output during the harvest. The plants irrigated with magnetized water (MW) exposed an elevation in vegetative growth and chemical components; photosynthetic pigments, total indole and phenols across the control plants **[6].**

**Aladjadjiyan (2002)[7]** demonstrated that magnetic addressing of seeds' irrigation had a possibility to amoleriate both the early growth and nutrient constituents of seedlings. It was observed that utilization of MW enhanced the growth development, improvement of the fresh weight, germinating energy and root length of Chick pea **[5].** Otherwise, **Mostafa zadeh-Fard *et al* (2011) [4]** mentioned that the recent use of physical techniques for plant growth prompting became more popular due to the less harmful impact on the environment. **Podlesny, *et al* (2004) [8]** exposed the beneficial effects of variable magnetic strengths on broad bean seeds prior to implanting and on development rate, seed germination, and yield. **Moussa (2011) [9]** stated that the irrigation of common bean plants with MW elevated remarkably the growth properties, photosynthetic activity and translocation adequacy of photo-assimilates as compared with control plants. **Hozayn *et al*., 2021 & 2022 [5 & 10]** indicated that the irrigation with magnetic water is looked one of the physical factors which induce alterations in biochemical components. Furthermore, increased assimilation and absorption of nutrients resulting an enhancement of broad bean growth and yield. Also, the improved effects of magnetized water and primo-magnetic seed treatments on the development, early growth and nutrient components of snow pea (*Pisums ativum* L) and chickpea (*Cicer arietinum* L) seeds were reported by **[11].**

Generally, **Da Silva and Dobr-anszki (2016) [12]** mentioned the valuable effects of magnetic fields on pre-sowing and seedling respectively. They reported the enhancement of seed germination, vigor, and plant growth rate, which affected significantly the final net output and yield. Moreover, the MW practice is easy to implement and has less adverse effect on the environment compared to other methods **[13].**

## 2. Materials and methods

To alleviation salinity stress on germination, growth, photosynthetic pigments, yield and yield components of faba bean; Laboratory using Faba bean (*Vicia faba* L; Var Nuberia-1) was conducted at Laboratory of Seed Technology Research Department, Field Crops Research Institute, Agriculture Research Center, Giza, Egypt. As well as Field Experiments were conducted at Experimental Research and Production Station belonged to NRC at El-Emam Malak Village, El-Nuberia Region, El-Beheira Governorate, Egypt during three winter seasons of 2019-2022.The laboratory and field experiments on Faba bean (*Vicia faba* L*;* var., Nubaria-1) were done as following procedure:

### 2.1 Laboratory experiments

Laboratory experiment was conducted at Laboratory of Field Crops Research Department, National Research Centre to compare between magnetized and un-magnetized seeds on germination traits of Faba bean. Magnetized seeds was prepared by soaking seeds in magnetized water (Water after path through magnetic unit produced by NRC; 0.5 inch; 0.18 - 0.20 Tesla) for two hours, then dry between with tissue, then the seeds will be ready to sowing. Seeds were kindly obtained from Legume Crops Department, Field Crops Institute, Agriculture Research Centre, Giza, Egypt.

**Germination procedure:** Germination test was conducted following to **[14]** guidelines. Twenty-five seeds of faba bean crop were planted in sterilized Petri dishes overlaid at the bottom with two sheets of Whitman filter paper, then set in an incubator at 20±2°C. Total numbers of germinated seeds were counted daily and the germination percentage was calculated at the twelfth day. Measurements were made on root and shoot seedling length (cm), root and shoot seedling dry weight (g). Also, Germination Index (GI), Germination Energy (GE), Germination Rate (GR; day), Speed Germination Index (SGI) and

Mean Germination Time (MGT; day) were estimated. Additionally, Seedling vigore-I (SV-I) and Seedling vigore-II (SV-II) were calculated as following equations:

**Seed germination (G; %)** = (No. of normal seedling/ total number of seeds) × 100; Germination percentage was conducted and defined as the total number of normal seedlings after twelve days

**Germination Energy (GE) =** $((N_1+N_2)/M) \times 100$; Where $N_1$, and $N_2$ constitute first and second counts; M represents the total number of sowed seeds.

**Germination Index (GI) =** $(N_1+N_2+N_3+N_4+\ldots)/T_i$; Where $N_1$, $N_2$, $N_3$ and $N_4$ represent first, second, third and four counts, etc, respectively. $T_i$ = count time. Seeds were looked germinated when the radical was at least 2 mm length.

**Germination Rate (GR):** It was calculated following to the formula; GR= a + (a +b) + (a + b + c) …….. (a + b + c + m) / n (a + b + c + m), where a, b, c are numbers of seedlings in the first, second and third count. "m" is the number of seedlings in the final count, while "n" is the number of counts.

**Mean Germination Time (MGT; day):** It was calculated relied on the equation: $MGT= (N_1 \times T_1) + (N_2 \times T_2) + (N_3 \times T_3) + (N_1 \times T_4)+ (Ni + Ti)/ N_1 + N_2 + N_3 + N_4+ \ldots N_i$; Where $N_1$,$N_2$,$N_3$ and $N_4$ represent first, second, third and four counts, respectively. While, $T_1$, $T_2$, $T_3$ and $T_4$ represent time of first, second, third and four counts respectively.

**Seedling root and shoot length (cm):** it was measured relied on 10 normal seedlings at twelve days after sowing.

**Seedling fresh and dry weight (g):** Ten normal seedlings at twelve days after sowing were calculated to estimate fresh weight. After that the seedlings were dried in hot-air oven at 85$^o$ C for twelve hours to gain the seedlings dry weight (g).

**Seedling Vigor-I (SV-I):** It was calculated based on the equation: **SV-I** = Germination percentage X seedling length (cm)

**Seedling Vigor-II (SV-II):** It was calculated based on the equation: **SV-II** =Germination percentage X seedling dry weight (g)

**Statistical analysis:** SPSS program Version 16 was used to analyze data. The independent *t*-test was applied to find the significant variations between magnetized and un-magnetized seeds treatments.

### 2.2 Field Experiments

Three Field experiments were conducted at Experimental Research and Production Station of NRC, Al-Emam Malek Village, Nuberia region, Al-Behaira Governorate, Egypt. The experiments were performed to compare between irrigation with magnetized and un-magnetized saline water under sprinkler and drip irrigation systems. The estimations of Faba bean growth, total chlorophyll, yield components, yield (ton fed$^{-1}$; fed=4200m$^2$) and nutritional value of seeds were done. The soil and irrigation water of the experimental site were analyzed following the method mentioned by **[15]**; Table 1.

**Table 1. Analysis of soil and irrigation water in the location of field experiments [16]**

| | Soil depth (0-30 cm) | | Irrigation water | |
|---|---|---|---|---|
| **Parameters** | **Un-Magnetized water (Un-MW)** | **Magnetized water (MW)** | **Un-Magnetized water (Un-MW)** | **Magnetized water (MW)** |
| **Particle size distribution** | | | | |
| **Coarse sand** | 48.20 | 54.75 | -- | .. |
| **Fine sand** | 49.11 | 41.43 | -- | .. |
| **Clay + Silt** | 2.69 | 3.82 | -- | .. |
| **Texture** | Sandy | Sandy | -- | .. |
| **pH (1:2.5)** | 8.93 | 8.60 | 8.28 | 8.43 |
| **EC(ds cm$^{-1}$; 1:5)** | 3.80 | 3.10 | 3.52 | 3.47 |
| **Ca $CO_3$ (%)** | 2.75 | 2.75 | -- | … |
| **Organic matter (%)** | 0.02 | 0.05 | -- | … |
| **Soluble cations (mq/100g soil)** | | | | |
| **$Na^+$** | 23.58 | 16.49 | 27.22 | 25.11 |
| **$K^+$** | 2.52 | 2.16 | 0.48 | 0.59 |
| **$Ca^{++}$** | 2.63 | 3.15 | 3.25 | 3.35 |
| **$Mg^{++}$** | 9.28 | 9.20 | 4.25 | 4.46 |
| **Soluble anions (mq/100g soil)** | | | | |
| **$CO^-_3$** | 0.00 | 0.00 | -- | … |
| **$HCO^-_3$** | 1.17 | 2.12 | 5.00 | 5.50 |
| **$Cl^-$** | 17.13 | 14.63 | 10.00 | 10.00 |
| **$SO^{--}_4$** | 19.71 | 14.26 | 20.20 | 20.20 |

**Cultivation procedures and design of experiment:** The soil was double time ploughed, ridged at 0.60 meter apart and divided into two plots with area (30 m long x 18 m width). During soil seedbed preparation for sowing, two hundreds kilograms calcium superphosphate (15.5% $P_2O_5$) fed$^{-1}$, and twenty kilograms N fed$^{-1}$ (20.60 N % as ammonium sulfate) were used. Recommended seeds of faba bean

(Variety; Nuberia-1) were coated just prior to planting with the bacteria inoculants, using 40% Arabic gum as adhesive agent. The seeds were sown in hills 15 cm apart at the 1st week of November in successive three seasons. Sprinkler and drip irrigation systems were achieved immediately after culturing and as requirements of the plants along the period of experiment. Potassium fertilizer (24 kg K $fed^{-1}$; 48 % $K_2O$ as potassium sulfate) was added after 35 days after seedling. Others recommended agricultural practices for sowing faba bean was applied following Agriculture Research Centre leaflet under this province circumstances. Faba bean was manually harvested on the second week of May at the 3 winter seasons.

Treatments: The field experiments were included 4 treatments,

- Un-magnetized water under drip irrigation system
- Magnetized water under drip irrigation system
- Un-magnetized water under solid sprinkler irrigation system
- Magnetized water under solid sprinkler irrigation system

Where magnetized saline water was obtained through passing saline well water into Magnetic Unit (diameter 2 inch, intensity 0.26-0.28 Tesla produced by NRC). While Un-Magnetized water was directly from well water. A hand-held Gauss meter (Hirst Magnetic Instruments, Ltd. UK; Figure 2.2.3) with Transverse probe Brand (model Gm07; accuracy ± 0.01%) was used to determine and assure the continuous exposure of the Magnetic field intensity. The design and layout of experiment was demonstrated in Figure 1.

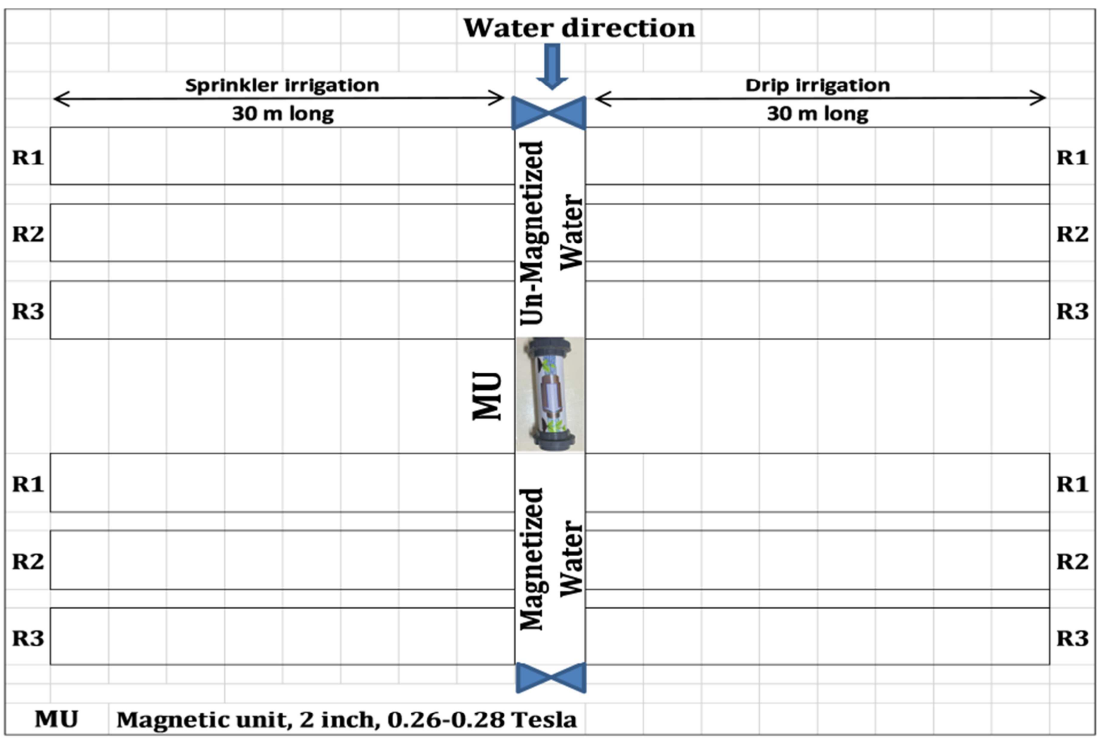


**Figure 1: Design of experiment layout under solid set sprinkler and drip irrigation systems.**

**Growth parameters:** Seventy-five days after sowing (DAS), ten plants were randomly picked from each plot to record plant height (cm), dry weight (g $plant^{-1}$), branches and leaves (no. $plant^{-1}$).

**Total Chlorophyll:** The total chlorophyll in leaves at seventy-five days after sowing (DAS) was estimated using SPAD Chlorophyll meter**.**

**Chemical analysis of leaves:** Macro (i.e. Ca, K, and Mg %) as well as microelement (i.e., Cu and Zn in ppm) constituents in leaves at 75 DAS were measured. Potassium content was determined using a flame photometer. Mg, Zn and Cu were estimated via the Atomic absorption spectrophotometer (Perkin Elemer 100 B).

**Yield and yield components:** At harvest, a random sample of ten guarded plants was chosen from each experimental unit to estimate Faba bean yield constituents (i.e., plant height (cm), branches, leaves and pods (no. plant$^{-1}$), pods and seeds weight (g plant$^{-1}$) and 100- seeds weight (g)). Plants in the two inner ridges were harvested by hand to estimate the total aboveground biological yield. For the same harvested plot, pods were separated and then dried in air to determine their seed yield/plot, which was then changed to feddan (Fed=4200 m$^2$). Multiple seeds and straw on biological yield, respectively determined harvest and crop indexes percentage.

**Nutritional value of dried seeds:** Macro; (Ca, K, Mg in %) and microelements (Cu and Zn in ppm) ingredients in dried seeds were estimated. Potassium content was determined using a flame photometer. Cupper, Magnesium and Zinc were determined using the Atomic absorption spectrophotometer (Perkin Elemer 100 B).

**Statistical analysis:** Data of Laboratory experiments and nutritional value of yielded seeds was statistically analyzed by Independent *t*-test using SPSS program Version 16. Field experiments data were designed in Randomized Completely Block Design (RCBD) and statistically analyzed using M-Stat program **[17].** Least Significant Difference ($LSD_{5\%}$) was implemented to compare mean values Also.

## 3. Results

### 3.1. Laboratory experiment

**Seed germination and seedling traits:**

Table 2 show significant increases were recorded regarding magneto-priming seed compared to untreated seed treatment (sowing dry seeds) on Germination Index (GI), Germination Energy (GE; %), Germination rate (GR; day), Seed Germination (G; %) and Speed Germination Index (SGI) of faba bean. The improvement reached 8.82, 8.82, 13.51, 36.36% and 6.87% in the above-mentioned parameters, respectively compared to untreated seed. Similar positive effect was observed in Mean Germination Time (MGT; day) where the seeds were faster germinated by 5.65% compared to control. Same table also show significant increases under magneto-priming seed compared to untreated seed treatment in root, shoot and seedling dry weight (g) as well as, root, shoot and seedling length (cm), seedling vigor-I and seedling vigor-II. The improvement reached 21.33, 33.33, 22.99, 21.26, 31.34, 23.09, 34.05 and 33.87% in the above-mentioned characters, respectively compared to untreated seed.

**Table 2. Comparison between magneto-priming and un-magnetized seeds in seed germination parameters of faba bean.**

| Treatment / Character | Mean | | *t sig.* | Increase (+) or decrease (-; %) over control |
|---|---|---|---|---|
| | Un-magnetized seeds | Magnetized seeds | | |
| **Germination (%)** | 56.67 | 61.67 | ** | 8.82 |
| **Germination Index (GI)** | 1.70 | 1.85 | * | 8.82 |
| **Speed Germination Index (SGI)** | 3.39 | 3.85 | * | 13.51 |
| **Germination Energy (GE; %)** | 27.50 | 37.50 | ** | 36.36 |
| **Germination Rate (GR; day)** | 0.54 | 0.58 | ns | 6.87 |
| **Mean Germination Time (MGT)** | 3.29 | 3.11 | ns | -5.65 |
| **Shoot seedling length (cm)** | 7.01 | 8.50 | * | 21.26 |
| **Root seedling length (cm)** | 1.55 | 2.03 | * | 31.34 |
| **Seedling length (cm)** | 8.56 | 10.53 | ** | 23.09 |
| **Shoot seedling dry wt. (g)** | 0.94 | 1.14 | * | 21.33 |
| **Root seedling dry wt. (g)** | 0.15 | 0.20 | ns | 33.33 |
| **Seedling dry wt. (g)** | 1.09 | 1.34 | * | 22.99 |
| **Seedling vigore-1 (SV-1)** | 4.85 | 6.50 | ** | 34.05 |
| **Seedling vigore-2 (SV-2)** | 0.62 | 0.82 | ** | 33.87 |

In this table and the following tables; ns= no significant; *, ** are significant at 0.05 and 0.01 probability according to independent *t*-test.

### 3.2 Field experiment

#### 3.2.1 Faba bean growth at 75 days after sowing (Average of three winter seasons of 2019-2022):

Data recorded in table 3 show that irrigation plots with magnetized saline water under sprinkler or drip irrigation systems increased significantly faba bean growth at 75 days after sowing compared to irrigation with un-magnetized saline water. As an average of magnetized saline water treatments over both irrigation systems, the improvement reached 15.71% in dry weight (g plant$^{-1}$), 10.92% in plant height, 20.74% in leaves (number Plant$^{-1}$), 15.48% in branches (number plant$^{-1}$), and 10.15% in total chlorophyll (SPAD) at seventy five-days after sowing, respectively. The same table also, displays that the values of above growth parameters were higher under drip than sprinkler irrigation systems (Plate 1). The improvement ranged between 8.16-12.28%. Same table show similar positive effect was observed in leaves contents with some macro as well as microelements (i.e. Ca, K, Mg and Na in percentage while, Cu and Zn in ppm) at 75 DAS. Where the improvement ranged between 14.05-24.57% in the above-mentioned elements except Na where decreased by 14.46%.

**Table 3. Comparison between irrigation with magnetized and un-magnetized saline water under sprinkler and drip irrigation systems in faba bean plant height (cm), branches and leaves (no. plant$^{-1}$), total chlorophyll (SPAD) some macro and microelements (i.e. Ca, K, Mg and Na in percentage while, Cu and Zn in ppm) in leaves at 75 days after sowing (Average of three winter seasons of 2019 – 2022).**

| Treatment | | Sprinkler irrigation | | Drip irrigation | | LSD 5% |
|---|---|---|---|---|---|---|
| Character | | Un-Magnetized saline water | Magnetized saline water | Un-Magnetized saline water | Magnetized saline water | |
| Growth parameters at (75 DAS) | Plant height (cm) | 50.00 | 55.11 | 55.00 | 61.34 | **1.78** |
| | Branches (no. plant$^{-1}$) | 3.36 | 4.01 | 3.57 | 4.46 | **0.24** |
| | Leaves (no. plant$^{-1}$) | 5.72 | 6.94 | 6.22 | 7.48 | **0.38** |
| | Dry wt. (g Plant$^{-1}$) | 2.42 | 2.89 | 2.74 | 3.41 | **0.18** |
| | Total chlorophyll (SPAD) | 22.33 | 23.67 | 23.11 | 26.39 | **1.37** |
| Macro and micro-elements in leaves (75 DAS) | K (%) | 2.88 | 3.69 | 2.18 | 2.61 | **0.10** |
| | Ca (%) | 1.59 | 1.93 | 1.68 | 2.09 | **0.12** |
| | Na (%) | 2.00 | 1.66 | 1.46 | 1.30 | **0.16** |
| | Mg (%) | 0.45 | 0.50 | 0.47 | 0.58 | **0.05** |
| | Zn (ppm) | 35.00 | 39.00 | 67.00 | 77.33 | **3.51** |
| | Cu (ppm) | 7.00 | 8.33 | 12.00 | 14.00 | **2.07** |

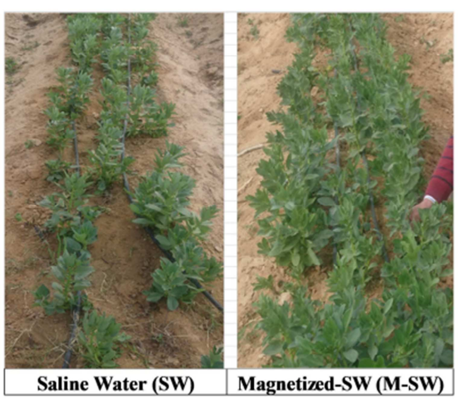


**Plate 1: Faba bean irrigated with saline and magnetized saline-water under drip irrigation systems in the Experimental Research and Production Station of NRC, El-Emam Malek Village, Nuberia region.**

### 3.2.2 Faba bean yield, yield components and nutritional value of dried seeds at harvest (Average of three winter seasons of 2019-2022)

Data tabulated in table 4 show that irrigation plots with magnetized saline water under sprinkler or drip irrigation systems increased significantly faba bean yield and its components at harvest compared to irrigation with un-magnetized moderate saline water. As an average of magnetized saline water treatments over both irrigation systems, the improvement reached 12.02% in plant height, 13.96% in pods number per plant, 21.18 and 18.00% in pods and seed weight (g plant$^{-1}$) and 4.92% in 100-seed weight (g), respectively. These increases reflected in improvement of biological, seeds and straw yields (ton fed$^{-1}$) by 20.28, 19.09 and 20.67%, respectively. Whereas, harvest and crop indexes slightly decreased by 0.91 and 1.15%, respectively compared untreated control over both irrigation system. The same table also, shows that the values of above faba bean yield and its components were higher under drip than sprinkler irrigation systems. The improvement ranged between 2.12 – 15.79%. Similar positive effect was observed in nutritional value in yielded seeds (i.e. K, Ca, Na, Mg in percentage, Zn and Cu in ppm) at harvest. Where the improvement ranged between 5.56 – 11.73% in the above-mentioned elements except Na where decreased by 7.55% (Table 5).

**Table 4. Comparison between irrigation with magnetized and un-magnetized saline water under sprinkler and drip irrigation systems in yield (ton fed$^{-1}$; fed=4200m$^2$) and yield components of faba bean (Average of three winter seasons of 2019 - 2022)**

| Treatment / Character | Sprinkler irrigation | | Drip irrigation | | LSD at 5% |
|---|---|---|---|---|---|
| | Un-Magnetized saline water | Magnetized saline water | Un-Magnetized saline water | Magnetized saline water | |
| **Plant height (cm)** | 72.56 | 83.11 | 84.22 | 92.56 | **1.37** |
| **Pods (no. Plant$^{-1}$)** | 9.89 | 11.33 | 10.78 | 12.78 | **1.56** |
| **Pods wt. (g Plant$^{-1}$)** | 44.34 | 48.89 | 46.62 | 61.33 | **2.37** |
| **Seed weight (g Plant$^{-1}$)** | 31.89 | 41.33 | 40.33 | 43.89 | **1.23** |
| **100-seed weight (g)** | 78.33 | 84.33 | 82.00 | 84.00 | **2.23** |
| **Biological yield (ton fed.$^{-1}$)** | 4.23 | 5.01 | 4.46 | 5.45 | **0.18** |
| **Seed yield (ton fed.$^{-1}$)** | 1.03 | 1.23 | 1.10 | 1.31 | **0.07** |
| **Straw yield (ton fed.$^{-1}$)** | 3.20 | 3.78 | 3.37 | 4.14 | **0.22** |
| **Harvest index (%)** | 24.43 | 24.58 | 24.57 | 23.97 | **ns** |
| **Crop index (%)** | 32.33 | 32.65 | 32.58 | 31.52 | **ns** |

**Table 5. Comparison between irrigation with magnetized and un-magnetized saline water under sprinkler and drip irrigation systems in nutritional value of faba bean dried seeds (Average of three winter seasons of 2019-2022)**

| Treatment / Character | | Sprinkler irrigation | | Drip irrigation | | LSD at 5% |
|---|---|---|---|---|---|---|
| | | Un-Magnetized saline water | Magnetized saline water | Un-Magnetized saline water | Magnetized saline water | |
| **Nutritional value of yielded seeds** | **K (%)** | 0.97 | 1.03 | 1.25 | 1.42 | **0.09** |
| | **Ca (%)** | 0.045 | 0.052 | 0.057 | 0.062 | **0.006** |
| | **Na (%)** | 0.176 | 0.161 | 0.124 | 0.117 | **0.012** |
| | **Mg (%)** | 0.05 | 0.06 | 0.06 | 0.06 | **ns** |
| | **Zn (ppm)** | 36.00 | 37.00 | 36.00 | 39.00 | **ns** |
| | **Cu (ppm)** | 5.00 | 5.33 | 5.67 | 6.00 | **ns** |

## 4. Discussion

Alterations in the growth of faba bean seedlings and its germination dynamics were noticed where remarkable elevations were recorded regarding applied magneto-priming seed (Table 1) compared to untreated seed treatment on seed Germination and seedling vigor. The elevation in germination of the seeds treated with magnetized water may be referred to the increase in the capability of water and nutrients absorption by the seeds and consequently result in a rising in germination percentage **[18]. Podleśna *et al.* (2019) [19]** mentioned that seeds treated with magnetic field revealed higher performance of amylolysis enzymes, which induces acceleration of the germination process compared to untreated seeds. Then, the magnetic field induced elevated IAA and $GA_3$ enzyme concentrations in seedlings and seeds. The previous observations indicates that the physical agents such as magnetic fields responsible for controlling the amount of IAA in the seeds and influencing the mechanism of its action. It is particularly essential in the starting phase of plant development. The prime role of these compounds is trigging of plant growth by boosting of its elongation growth. These data are in agreement with those mentioned by **[20]** where they demonstrated that a magnetic field induced a significant elevation in the germination rate of numerous crops (i.e. pea, radish, broad bean seeds). It is clear that the treatment of the seeds with a magnetic field possesses beneficial impact on the growth components of broad beans than untreated seeds **[21].**

Under drip or sprinkler irrigation system, data show that irrigation faba bean plants with magnetized saline water increased significantly faba bean growth and total chlorophyll at 75 days after sowing (Table 2) compared to irrigation with un-magnetized saline water. The given data may be due to the role of magnetized water in enhancement of absorption and nutrients' assimilation thus promoting plant growth and dry weight **[18].** The elevation in dry weight/plant due to irrigation with magnetized water may be a result of the elevation in all growth components. The elevations involved endogenous promoters (IAA), photosynthetic pigments, total pigment contents, as well as protein biosynthesis **[9].**

Magnetized water (MW) can enhance absorption of nutrients by roots via stimulating differentiation of root tissues and increasing of radicle elongation **[6].** Consequently, MW treatment can enhance absorption of water and nutrition in crops and improve the economic features of crops during later phases **[32]**. Magnetized brackish water can enhance the accumulation of total biomass of cotton seedlings by ameliorating the dry matter ratio of roots **[23]**. The same observation was noticed on many crops **[9; 23].**

Faba bean plant height at reaping phase was significantly elevated under magnetized water. This elevation due to increase ions mobility or boost ions uptake under magnetic field treatment. The resulted biochemical alterations or changed enzyme activities, which might be lead to better photosynthesis stimulation, **[24]**. This result was asserted by those given by **[9]** they interpreted that MW elevated plant height, root and shoot dry weights of faba bean. **Sutiyanti and Rachmawati (2021) [25]** exposed that the electromagnetic fields from magnetization rise the plant growth regulator which stimulated phenylalanine ammonia-lyase during cell differentiation. Plants irrigated with MW easily lift mineral from the soil with no residue formed on the soil surface. Additionally, enhancement of vegetative growth and the ripening of plant earlier than normal **[26]**. Magnetized water treatment also significantly influenced plant biomass as indicated by the elevation in fresh weight of root and shoot. This finding is harmonized with the study of **[27]** they displayed that an elevation in plant height is also reflected as increasing in biomass with MW treatment. Furthermore, **[26]** mentioned that MW induced a remarkable increasing in cowpea biomass, stomatal performance and water use efficiency. It is supported that magnetic treatment influences the physical and biochemical reaction of water that consequently affects plant biochemical reactions, comprising enzymatic activity. Moreover, the magnetically treated water has been utilized to boost yielding in desert soils, which have circumstances of high salinity and calcification. Magnetic treatment boosts the water and nutrient uptake as well as cell permeability leading to an elevation in plant biomass **[26]**. The studies revealed that pre-planting treatment with a magnetic field influenced the course of analyzed biochemical and physiological processes. Furthermore, the rise in photosynthetic pigments may be referred to increasing ions uptake and improved mobility under magnetic field, which leads to a better photo-stimulation in plants **[28]**. The stimulatory impact of MW on photosynthetic pigment constituents may be attributed to the changeable effect of magnetic treatment on the key of cellular processes as gene transcription which play a substantial role in cellular processes alteration **[9].** The similar data was gained by **[29]** who demonstrated an elevation in chlorophyll content particularly evident after short time exposure to a magnetic field. **Hozayn and Abd El-Qodos (2010) [9]** found a significant increase in chlorophyll a and b constituents in wheat using magnetically treated water. They attributed this elevation to the induction of better ion uptake as well as mobility during growth. In the same manner, **[27]** mentioned the useful changes in the physical and chemical properties of water for plant systems after magnetic treatment, leading to cell activity improvement and crop development and productivity. Moreover, **[30]** demonstrated that magnetized or ionized irrigation water was beneficial for the absorption of soil water by winter wheat, which was reflected in the enhancement of growth parameters. According the view of several studies, it is evident that electromagnetic treatments change seed germination, relative growth rate, root growth, chlorophyll contents, cell membrane properties, and cell division by inducing alterations in the metabolism of plant cells **[31].**

Irrigation with water passed through magnetic unit (2 inch, produced by NRC; 0.26-0.28 Tesla) induced positive significant effect in faba bean yield and its components at harvest under sprinkler or drip irrigation systems compared to untreated treatment (Table 4). In this accordance, **[32]** disclosed that irrigating broad beans with 2 min magnetically treated water resulted in an elevation in the mass of pods and seeds, number of seeds and branches, plant height, and consequently whole mass of the plant. Additionally, these findings coincided with the results obtained by **[18;23;27]** where higher yields were gained for maize, pepper, tomato and wheat. **Hilal and Helal (2003) [33]** concluded that the increased in seed yield was a consequence of the elevated number of pods of broad bean due to magnetized water treatment. **Baghel *et al.* (2016) [34]** revealed that soybean seeds which treated with static magnetic field had higher numbers of pods and the highest yield. Moreover, increased carbon and nitrogen fixation, in non-saline as well as saline statuses. **Moussa, (2011) [9]** mentioned that magnetized water irrigation increased significantly the total plant yield. These results are in the agreement with that of **[6]** who stated translocation efficiency as well as improvement of growth parameters, growth hormone and photosynthesis.

Application of magnetized water also induced positive effects in nutritional value of yielded seeds at harvest under sprinkler or drip irrigation systems compared to control treatment (Table 5**)**. In this regards, previous results by **[22;35;36]** recorded that magnetized water increased Potassium %, Calcium %, Magnesium %, Zinc (ppm) and copper (ppm) but decreased Sodium % concentration in faba bean leaves and seeds. The elevation in tested macro and micro-elements due to the influence of magnetic field is attributed to increasing ions mobility and absorption in the root zone. According to the element magnetic field, there is a great variance from one element to another. **Atak, *et.al*, (2007) [29]** they concluded that magnetic field had a positive impact on diminishing the surface tension and elevation of viscosity. Water was more stabilized with treatment of magnetic field with least molecular energy while utmost in activation energy **[37].** Moreover, **[38]** demonstrated that water is a key agent in nutrient uptake by root, mass diffusion and flow. Roots obstruct more nutrients especially calcium and magnesium. Minimized sodium concentration in case of irrigation with magnetically treated saline water compared to the irrigation with saline water propose restricted sodium loading into output. Electromagnetic treatment may aid to mitigate the sodium toxicity at cell level via detoxification of Na. this obtained either by intercepting the entry of sodium at membrane level or by diminished absorption of sodium by plant roots. Alternatively, the decreasing of sodium concentration may be linked with dilution of salts **[39].**

## 5. Conclusion

Magnetized water had a substantial role in minimize the negative impact of salinity water stress on faba bean plants. Results of the current study revealed the positive effects of magnetized water on faba bean growth as well as water parameters than that the control. It seems that utilization of magnetized water can result in improving quality and quantity of faba bean (*Vicia faba*, L.) crop. Seeds dealed with the magnetic field exposed greater dynamics of weight elevation at the imbibition time than control seeds. The pre-planting seed treatment with a magnetic field possessed a positive impact on the development and growth of seedlings in addition to their dry matter in comparison to control.

It proposed that magnetic water could enhance translocation efficiency of photo-assimilates, photosynthetic activity and defense system in faba bean plants. Generally using magnetic water addressing could be a promising approach for agricultural enhancement.

## 6. Reference

1. Labuda, H. (2012). Flowering and characteristics of useful traits of some faba bean (*Viciafaba* L. var. major Harz) cultivars and breeding lines. ActaAgrobot., 65: 139-148.
2. Haciseferoğullari, H.; Gezer, I. ; Bahtiyarca, Y. and Mengeş, H.O. (2003). Determination of some chemical and physical properties of Sakizfaba bean (*Viciafaba* L. Var. major). J. Food Eng., 60: 475-479.
3. Kumawat, S. ; Gothwal, D.K. ; Kumawat, K.R. and Sharma, R.K.M. (2017). Effect of salt stress on seed germination and early seedling traits in fenugreek (*Trigonellafoenum-graecum* L.) genotypes grown under different salinity levels. J. Pharmacognosy and Phytochemistry, 6(5): 776-781.
4. Mostafazadeh-Fard, B. ; Khoshravesh, M.; Mousavi, S.F. and Kiani, A,R. (2011). Effects of magnetized water and irrigation water salinity on soil moisture distribution in trickle irrigation. J. Irrig. Drain. Eng., 137: 398-402.
5. Hozayn M.; Abd El-Monem A.A. and El-Mahdy A.A. (2022). Alleviation salinity stress in germination, seedling vigor, growth, physiochemical, yield and nutritional value of Chickpea (*Cicer arietinum* L) using magnetic technology in sandy. Egypt. J. Chem., 65(SI13B): 1317-1331.
6. Hozayn, M. and Abd El-Qodos, A.A. (2010a). Irrigation with magnetized water enhances growth, chemical constituent and yield of

chickpea (*Cicer arietinum* L.). Agric. & Biolo. J. North America, 1(4): 671-676.
7. Aladjadjiyan, A. (2002). Study of the influence of magnetic field on some biological characteristics of Zeamais. J. Central Europ. Agric., 3(2):89-94.
8. Podlesny, J.; Pietruszewski, S. and Podlesna, A. (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. Intern. Agrophy., 18(1): 65-71.
9. Moussa, H.R. (2011). The impact of magnetic water application for improving common bean (*Phaseolus vulgaris* l.) production. New York Sci. J. 4(6):15-20.
10. Hozayn, M.; Elaoud, A.; Cheikh, O.; Abd El-Monem, A.A. and Ben Salah, N. (2021). Effect of magnetic field on growth and yield of barley treated with different salinity levels. Arab. J. Geosciences, 14(8): 701. DOI:10.1007/s12517-021-07077
11. Grewal, H.S. and Maheshwari, B.L. (2011). Magnetic treatment of irrigation water and snow pea and chickpea seeds enhances early growth and nutrient contents of seedlings. Bioelectromagnetics, 32(1): 58–65. doi: 10.1002/bem.20615.
12. Da Silva, J.A.T. and Dobr_anszki, J. (2016). Magnetic fields: How is plant growth and development impacted?. Protoplasma, 253(2): 231-248.
13. Pauzaite, G.; Malakauskiene, A.; Nauciene, Z.; Zukiene, R.; Filatova, I.; Lyushkevich, V.; Azarko, I. and Mildaziene, V. (2018). Changes in Norway spruce germination and growth induced by pre-sowing seed treatment with coldplasma and electromagnetic field: Short-term versus long-term effects. Plasma Processes and Polymers, 15(2):1700068.
14. I□ta, L.K.; Pérez-Luna, V.H. and López, G.P. (1999). Surface-grafted, environmentally sensitive polymers for biofilm release. Appl. & Environ. Microbiol., 65(4): 1603-1609.
15. Chapman, H.D. and Pratt, P.F. (1978). Methods of Analysis for Soils, Plants and Water. Univ. of California, Div. Agric. Sci., Oakland.
16. Hozayn M; Abd El-Monem AA.; El-Mahdy AA and Al-Ashkar NM (2022). Alleviation Salinity Stress on Germination, Seedling Vigour, Growth, Yield and Nutritional Value of Groundnut (*Arachis Hypogaea* L) growing in sandy soil using Application of Magnetic Technology. Egypt. J. Chem. Vol. 65, No. SI13B pp. 1317 – 1331.
17. MSTAT-C (1988) MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University, East Lansing.
18. Abd El-lateef, M.M., and Mutwali, E.M. (2020). Effect of magnetized water on germination and some growth characters of broad bean (*Vicia faba* l.). Asi. J. Agric.& Food Sci., 8(4): DOI:10.24203/ajafs.v8i4.6145.
19. Podleśna, A.; Bojarszczuk, J. and Podleśny, J. (2019). Effect of pre-sowing magnetic field treatment on some biochemical and physiological processes in faba bean (*Vicia faba* L. spp. Minor). J. Plant growth regul., 38: 1153-1160.
20. Podleśna, A.; Gładyszewska, B.; Podleśny, J. and Zgrajka, W. (2015). Changes in the germination process and growth of pea in effect of laser seed irradiation. Int. Agrophys, 29(4): 485-492.
21. Podlesny, J.; Pietruszewski, S. and Podlesna, A. (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. Intern. Agrophy., 18(1):65-71.
22. Hozayn, M.; Ismail, S.M.; Abd El-Monem, A.A. and Darwish, M.A. (2019): Magnetically treated brackish water new approach for mitigation salinity stress on sunflower productivity and soil properties under South Sinai Region, Egypt. Alex. Sci. Exch. J., 40(3): 441-446.
23. Liu, X.; Zhu, H.; Meng, S.; Bi, S., Zhang, Y., Wang, H., Song, C. and Ma, F. (2019). The effects of magnetic treatment of irrigation water on seedling growth, photosynthetic capacity and nutrient contents of Populus euramericana Neva under NaCl stress. Acta Physiol. Plant., 41(11): 1-13.
24. Dhawi, F. and Al-Khayari, J.M. (2009). The effect of magnetic resonance imaging on date palm (*Phoenix dactylifera* L.) elemental composition. Comm. Biometry Crop Sci., 4(1): 14-20.
25. Sutiyanti, E., and Rachmawati, D. (2021). The effect of magnetized seawater on physiological and biochemical properties of different rice cultivars. Biodiv. J. Biol. Div., 22(6): 3083-3091.
26. Sadeghipour, O. and Aghaei P 2013 Improving the growth of cowpea (*Vigna unguiculata* L.Walp.) by magnetized water. J. Bio. and Env. Sci., 3(1):37-43.
27. Maheswari, B.L. and Grewal, H.S. (2009). Magnetic Treatment of Irrigation Water: It's Effect on Vegetables Crop Yield and Water Productivity. Agric. Water Manag., 96(8): 1229-1236.
28. Pietruszewski, S. (1999). Influence of pre-sowing magnetic biostimulation on germination and yield of wheat. Int. Agrophys. , 13(2): 241-244.
29. Atak, C.; Celik, C.; Olgun, O.; Alikamanolu, A. and Rzakoulieva, A. (2007). Effects of magnetic field on soybean tissue culture. Biotech. & Biotechnol. Equip., 21: 166171.
30. Zhao, B. and Bilen, H. (2021). Dataset condensation with differentiable siamese augmentation. Proceedings of the 38th International Conference on Machine Learning, PMLR 139:12674-12685.
31. Shine, R.; Brown, G.P. and Phillips, B.L. (2011). An evolutionary process that assembles phenotypes through space rather than through time. Proceedings of the National Acad. Sci., 108(14): 5708-5711.

32. Altalib, A.A.; Ali, W.M.; Al-Ogaidi, A.A.M. and Al-Zubaidy, S.A.S. (2022). Effects of magnetic field treatment of broad bean seeds and irrigation water on the growth and yield of plants. Irrigation and Drainage, 71(5): 1159-1167.
33. Hilal, M.H., Helal, M.M., 2003. Application of magnetic technologies in desert agriculture. Seed germination and seedling emergence of some crops in a saline calcareous soil. In: Proc. II Int. Conf. Impact of Electromagnetic Fields in the Agricultural Environment, Agrolaser, September 8–10, Lublin, Poland.
34. Baghel, L.; Kataria, S. and Guruprasad, K.N. (2016). Static magnetic field treatment of seeds improves carbon and nitrogen metabolism under salinity stress in soybean. Bioelectromagnetics 37(7):455-470.
35. Hozayn, M.; Salama, M.; Abd El Monem A.A. and Hesham, A.F. (2016 b). The impact of magnetized water on the anatomical structure, yield and quality of potato (*Solanum tuberosum* L.) grown under newly reclaimed sandy soil. Res. J. Pharma. Biolog. & Chem. Sci. 7(3):1059-1072.
36. Ben Hassen, H.; Hozayn, M.; Elaoud, A.; Attia, A.A. (2020). Inference of Magnetized Water Impact on Salt-Stressed Wheat. Arab. J. Sci. & Eng., 45(6): 4517-4529.
37. Mghaiouini, R.; Abderrazzak, G.; Benzbiria, N.; Monkade, M. and El Bouari, A. (2020b). Elaboration and physico-mechanical characterization of a new eco-mortar composite based on magnetized water and fly ash. J. Ecolog. Eng., 21(4): 225-254.
38. Tisdal, S.; Nelson, W.; Beaton, J. and Havlin, J. (1993). Soil fertility and fertilizers. 5th Ed., Machmillan Publishing Company. U.S.A.
39. Hozayn, M.; Abdallha, M.M.; Abd El-Monem, A.A.; El-Saady, A.A. and Darwish, M.A. (2016a) Applications of magnetic technology in agriculture, a novel tool for improving crop productivity (1): Canola. Afr. J. Agric. Res., 11(5):441-449.