OPEN ACCESS Plant Protection, 09 (04) 2025. 1001-1012 DOI:10.33804/pp.009.04.5939

Check for updates

Available Online at EScience Press
Plant Protection
ISSN: 2617-1287 (Online), 2617-1279 (Print)
http://esciencepress.net/journals/PP

Research Article

Effects of Physical Water Treatment on Reducing Irrigation Water Salinity in *Vicia faba* L.

Shatha Mohammed Hamza, Zainab AbduAlwahid Saeed

Department of Biology, Faculty of Sciences, University of Basrah, Iraq.

ARTICLE INFO

Article history
Received: 8th October, 2025
Revised: 24th December, 2025
Accepted: 26th Decemberl, 2025

Keywords
Vicia faba L.
Irrigation water salinity
Magnetic water treatment
Pottery water treatment
Plant growth and biochemical responses

ABSTRACT

Salinity is one of the components of the abiotic stress that has an adverse impact on the growth and yield of the plants. The current study reported in this paper was intended to measure the effect of using the magnetic and pottery-treated water with the growth and biochemical characteristics of *Vicia faba* L. under salty environment. Saline water with 7 dS m^{-1} was used to irrigate plants which brought about significant reductions in growth parameters and increase in plant height, root length, number of leaves, and nodule formation relative to control and individual treatments of magnetic and pottery water. Interestingly, there was a considerable ($p \leq 0.05$) enhancement in all the measured growth characteristics when magnetically treated water was applied together with pottery water in comparison with the salinity treatment alone, and control. Moreover, this mixture had a positive effect on the biochemical parameters increasing the content of total chlorophyll, the level of soluble proteins, and the activity of major antioxidant enzymes, such as catalase and superoxide dismutase. On the whole, the results of the study prove that the combination of magnetically treated water and pottery water is an effective intervention in preventing the negative impact of salinity and results in morphological and biochemical enhancement of *V. faba*. This would provide a viable solution of promoting the growth of plants and their tolerance against salty environment.

Corresponding Author: Shatha Mohammed Hamza
Email: shatha.hamza@uobasrah.edu.iq

Introduction

The issue of salinity and its effects on agricultural production is a key research topic because of its role in ensuring food security to the ever-growing population. It is a global and widespread problem in many countries where an abnormal decline in arable land has been observed recently due to environmental changes, particularly climate change. The presence and increase of salinity in the soil causes root damage and affects the plants' ability to absorb water. On the other hand, salinity interacts with nutrients, causing toxicity and wilting in the plants (Hozayn et al., 2024).

The salt elements in the soil vary depending upon the kind of soil, quality of irrigation water, and edaphic factors and environmental conditions. The most common elements associated with soil salinity are Na+ and Cl-. The excessive accumulation of these salts causes changes in the physicochemical properties of the soil, impairs availability of nutrients, and disrupts uptake and translocation of water and minerals in plants and greatly affects plant growth and productivity. Consequently, soil aeration decreases, causing an increase in the osmotic potential that prevents the plant from absorbing water (Iqbal et al., 2024).

Vicia faba L. is an annual plant belonging to the Fabaceae family. It is a leguminous plant that grows to a height of approximately two meters. Its flowers are white with black patches, and its fruits are in the form of pods in which large seeds are found connected to the inner edge of the fruit (marginal placentation). This plant, originated in China, is grown in many parts of the world and is widely spreading to other parts (Bullo et al., 2021). The crop is of great economic importance due its nutraceutical value and is equally used by humans as food and by animals as feed (Merga et al., 2019). The seeds of faba bean contain about 35% protein and possess substantial amounts of essential amino acid lysine, and are a rich source of carbohydrates providing up to 58%.

The recent research investigations have highlighted the potentiality of pottery technology in improving the quality of the water, that is be utilized in the irrigation process by converting it into a more dynamic version of water, which is generally referred to as living water. (Padilla and Sanchez 2021) carried out experiments and found that water trapped in clay pots is more active than normal water. The positive effects have also been observed in rice (Hung et al., 2016), wheat (Han et al., 2018) and chili (*Capsicum*) plants where pottery water promoted the growth and development of plants and their recovery following the exposure to stresses. Equally, (Hossain, 2023) observed an increase of vitamin C concentration and yield in cherry tomato plants under pottery water irrigation.

The conversion of water to high-energy content has been found to be more effective in seed germination and plant growth compared to traditional water, which eventually elevates crop production. In particular, magnetized or physical water has shown a great number of positive results on plant development. (Liu et al., 2019) have observed increased nutrient level and photosynthetic pigment build up in *Populus euromericana* plants irrigated with magnetized water. Likewise, (Hozayn et al., 2022) found that salinity stress was reduced during germination and seedling vigor was enhanced in chickpea (*Cicer arietinum*) when magnetized water was applied.

The molecular properties of magnetized water are modified as the molecules of water get aligned at the wide angles, making interactions with nutrients more effective so that the nutrients can be more efficiently engaged (Mohammed and Aml, 2024). When water is exposed to a magnetic field, molecular and atomic structures are altered, such as viscosity, boiling point and polarization. Linear and cyclic chains of molecules are formed and the absorption of ultraviolet radiations is increased as compared to the absorption by the untreated water. These structural transformations result in the molecular clustering and alteration of the transition dipole moment of electrons in water molecules, which results in the enhancement of water activity (Vaskina et al., 2020).

The current investigation was, therefore, carried out to examine how magnetized water and pottery water interact with one another in relation to the growth, developmental characteristics and biochemical characteristics of *V. faba* under saline irrigation.

Materials and methods

The current trial was performed in the Department of Biology, College of Science, University of Basrah, Iraq, in a controlled growth chamber from October 2023 to January 2024.

Seed preparation

Seeds of faba bean were provided by the Department of Crops, Faculty of Agriculture. To ensure high viability, homogenous, healthy, and uncontaminated seeds were taken. Surface sterilization of the seeds was done with 3% sodium hypochlorite and then the seeds were thoroughly rinsed a number of times in distilled water to eliminate any traces of disinfectant. These disinfectant seeds were put in Petri plates lined with filter paper and each dish as moisturized with 5 ml of distilled water. The petri plates were kept for 5 days at room temperature. The germination of the seeds was deemed successful when the radicle attained the length of 2 mm.

Preparation of pots and growth conditions

The germinated seeds were transplanted into polyethylene pots (30 × 15 cm) with 1 kg of a soil mixture which comprised of agricultural soil and peat moss in an equal portion (50%: 50%). The physicochemical characteristics of the experimental soil are given in (Table 1). The pots were kept in a controlled growth chamber at a temperature of 27-32°C, with 85 percent relative humidity and a light period of 16 h and darkness period of 8h. Pots were irrigated with 500 ml of treated water twice a week.

Table 1. Physicochemical properties of the experimental soil.

pH* (1:2.5)	EC** (dS m^{-1})	Soluble Cations (mg L^{-1})				Soluble Anions (mg L^{-1})			
6.89	1.28	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
		6.22	5.37	1.22	2.15	6.17	5.11	2.37	3.78
Soil Texture (%)				Plant Nutrients (mg kg^{-1})					
Coarse	Fine	Silt	Clay	OM	P	K	B	Zn	Cu
25.30	31.43	15.22	26.11	18.24	3.17	68.32	21.55	0.78	4.11

* Soil water suspension; ** soil paste.

Collection and analysis of soil

The soil samples were taken at the depth of 15-30 cm from Al-Hawta region, an agricultural area in Basrah, around 20.2 km north of Basrah, Iraq. The soil samples were rinsed with sterile water and allowed to dry in the sunlight for 3 days. After the soil was dried, it was properly mixed with peat moss in equal quantities which then served as the growth medium for the experiment pots.

Water treatments

The physical and chemical properties of the irrigation water used in the experiment are given in (Table 2). Five irrigation types were tested which are given below:

T0 = Control (distil water),

T1 = Salinity treatment (7dS/m),

T2 = Pottery water,

T3 = Magnetic water,

T4 = A mixture of pottery water and magnetized water.

Salinity water

A dS m^{-1} concentration of saline solution was made by adding an equivalent amount of NaCl into distilled water as follows:

$$M = \frac{Wt(g)}{Mwt} \times \frac{1000}{V(mL)}$$

Pottery water

Pottery water was made using earthen (pottery) pots which were procured from a nursery and filled with 5 L of distilled water. The pots were made of 85 percent of clay, 10 percent silt and 5 percent sand. The water was left in these pots for overnight (24 h) which was slowly absorbed and dripped through the porous surface of the bottom of the pottery.

Magnetic water

Magnetic water was prepared by putting four ceramic magnets (5 cm in diameter, 2 cm thick), procured from an electrical station, around a body of water (a plastic tank with 500 L of water). The ceramic magnets were allowed to remain for 10 min. The similar process was performed thrice prior to their application to the plants. Magnetometer (German-made) was used to measure the magnetic current which was recorded to be 135 mT.

Preparation of mixed water

The preparation of mixed water involved the exposure of water stored in a pottery to a magnetic field of 135 mT by adopting the same procedure employed in preparing the magnetized water.

Table 2. Physicochemical properties of the water used in the experiment.

Type of water	pH	EC (dS m^{-1})	Soluble cations (mg L^{-1})				Soluble anion (mg L^{-1})			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
Control	7.11	2.44	3.35	4.21	1.12	2.23	5.33	6.5	3.08	3.87
Magnetic	6.81	2.45	3.03	4.02	1.4	2.34	5.1	6.1	2.22	3.82
Pottery	7.23	2.54	3.78	4.98	4.79	2.98	5.03	5.27	2.03	3.43
Mixed	7.47	2.67	3.1	3.17	3.13	3.88	4.32	5.11	2.03	2.67

Type of water	pH	EC (dS m-1)	Water nutrient (mg L^{-1})					
			NH_4^{+}	NO_3^{-}	P	B	Zn	Cu
Control	7.11	2.44	3.25	14.94	0.03	0.55	0.02	0.02
Magnetic	6.81	2.45	2.43	15.22	0.03	0.53	0.02	0.03
Pottery	7.23	2.54	2.79	18.65	0.05	0.53	0.03	0.04
Mixed	7.47	2.67	2.34	18.89	0.05	0.56	0.04	0.04

Growth characteristics

At the termination of growth period, the plants were uprooted meticulously and the roots were washed tenderly using distilled water to remove soil particles avoiding damage to root nodules. The growth variables were quantified with a standard ruler. The parameters studied included plant height, root length, number of leaf per plant and diameter and quantity of root nodules.

Chemical characteristics

Soluble protein content (mg g^{-1})

Soluble protein contents in the leaves of *V. faba* exposed to varying water applications were measured by employing the protocol described by (Bavei et al., 2011). Briefly, 0.5 g of fresh leaf tissue was ground in liquid nitrogen and homogenized in 0.1 M phosphate buffer (pH 7.0). To inhibit protease activity, phenylmethylsulfonyl fluoride (PMSF) was used. The soluble protein concentration was measured through the addition of bovine serum albumin that was used as the standard and the absorbance of the solution was ultimately measured at 595 nm by using a spectrophotometer.

Determination of the antioxidant enzyme activity

The method by (Ying et al., 2018) was used to determine the activities of antioxidant enzymes. Fresh leaf samples were taken (0.5 g), crushed in liquid nitrogen, and the homogenate was further processed in order to obtain pure filtrate. The filtrate was applied in the enzyme antioxidant assays of catalase (CAT, units min^{-1} g^{-1} fresh weight) and superoxide dismutase (SOD, units g^{-1} fresh weight).

Catalase (CAT) assay (EC 1.11.1.6)

The catalase activity was measured according to (Hande and Arabaci, 2016). The reaction mixture consisted of 0.5 ml of 100 mM H_2O_2 (final concentration 2.5 mM) prepared in phosphate buffer and enzyme extract, added to quartz cuvettes. The decrease in absorbance was recorded at 240 nm at 10-s intervals for 3 min using a UV-visible spectrophotometer. The blank contained the reaction mixture without enzyme extract.

$$\text{Unit activity} = \frac{\Delta A \, . \, V_{total}}{\epsilon \, . \, V_{sample}}$$

Where ΔA represents the change in absorbance per minute; V_{total} is the total reaction volume (ml); ϵ is the extinction coefficient (6.93×10^{-3} mM^{-1} cm^{-1}); and V_{sample} is the volume of enzyme extract added to the reaction mixture (ml).

The enzyme activity was measured by using the given below formula:

$$\text{Activity of enzyme (U/min/f.w)} = \frac{\text{Unit activity}}{\text{Protein content}}$$

Super oxide dismutase of SOD assay (EC 1.15.1.1)

The activity of SOD was estimated by adding 0.5 ml of the enzyme extract to a reaction mixture consisting of 13mM methionine, 50mM phosphate buffer, and 0.1mM EDTA. The absorbance was measured at 560 nm and estimation of enzyme was calculated according to formula given by (Gong et al., 2005), where the extinction coefficient is (12.8×10^{-3} mM^{-1} cm^{-1}).

Total chlorophyll estimation

One gram of fresh leaf tissue was ground in a ceramic mortar using 5 ml of 80% (v/v) acetone. The homogenate was filtered to separate the filtrate from the residue, ensuring complete extraction of the pigments. The total chlorophyll content in the filtrate was then determined spectrophotometrically by measuring absorbance at 645 and 663 nm. Eighty percent acetone was used as the blank. Total chlorophyll content was calculated using the formula described by (Musa and Hassan, 2016).

$$\text{Total chlorophyll} = [20.0(A_{654}) + 8.02(A_{663})] \, . \frac{v}{w}$$

Where

A_{654} = Absorbance measured at 645 nm,

A_{663} = Absorbance measured at 663 nm,

v = Total volume of the acetone extract (ml),

w = Fresh weight of the leaf tissue used (g).

Statistical analysis

This experiment was conducted using a randomized complete block design (RCBD) with five treatments that were applied 5 times. The analysis of variance (ANOVA) was used to analyze all the data. The LSD test was employed in the comparison of the treatment means with a probability level of p = 0.05. Correlation coefficients were calculated to evaluate strength and direction of the relationship that existed between treatments. All forms of analyses were done with SPSS statistical software (version 25).

Results and Discussion

Growth parameters

Effect of saline water

As can be seen in the results provided in Table 3 and Figure 1 and Figure 2, salinity had considerable impacts on the vegetative growth variables viz., plant height, root length, numbers of leaves as well as the root diameter of nodules ($p \leq 0.05$). Saline irrigation reduced drastically the height and root length of the plant (15.22 cm and 17.31 cm respectively) compared to the height and length of the root of control treatment (24.45 cm and

35.54 cm respectively).

Likewise, there was a significant reduction ($p \leq 0.05$) in number of leaves. As far as root nodulation is concerned, it showed significant sensitivity to salinity, both in number and diameter of nodules which decreased to by approximately 55% compared to the control treatment.

These results are in line with those earlier reported by (Shanko et al., 2017) in chick pea (*Cicer arietinum*), by (Ying et al., 2018) in *Schizonepeta tenuifolia*, and in soybean by (Jahan et al., 2025). All the researchers proved significant declines in plant growth parameters and vegetative characters under saline conditions.

Salinity, linked to irrigation water, is regarded as one of the main factors which contribute to salinization of soils in agricultural systems (Samoona et al., 2023). Excessive amounts of salts, mainly NaCl, cause disruptions in nutrient availability in the soils and interfere with transport of essential ions across cell membranes of roots. This interference impairs the uptake and translocation of vital nutrients and minerals, specifically N, which is crucial for the synthesis of proteins and general growth of plants (Fatima et al., 2024). Moreover, damage caused to cell membranes by salts lowers photosynthetic rate and efficiency. This is due to a reduction in number of plastids and fluctuations in light absorption processes, eventually resulting in degradation of chlorophyll and reduced photosynthesis.

Effect of pottery water

Plant growth was greatly boosted with pottery-treated water, and the vegetative performance was increased by approximately 35 percent. There was a significant change ($p \leq 0.05$) in the plant height, root length, number of leaves, and root nodule characteristics (Table 3 and figure 1,2). These findings show that, treatment of water with pottery was effective to address the negative aspect of salinity on *V. faba* plant irrigated with saline water at dS m^{-1}.

The increased salinity tolerance of *V. faba* to pottery water is consistent with the literature views presented by (Huang et al., 2016) in rice, (Rahayu, 2022) in *Capsicum annuum*, and (Hossain, 2023) in cherry tomatoes. These experiments revealed that pottery treated water had a positive effect on the growth of plants in various indicators. This enhancement is presumably explained by adsorption of sodium ions by the pottery material that lowers the concentration of toxic salts in irrigation water. By definition, pottery has the advantage of being a natural filtration medium, and it simplifies the process of eliminating the surplus of ions by adsorbing them.

Effect of magnetic water

(Table 3 and Figure 1, 2) indicates that irrigation with salinity conditions (dS m^{-1}) using magnetized water was significantly beneficial to all the measured vegetative characteristics of *V. faba* and generally, there was an improvement in all characters by about 38 percent relative to saline water ($p = 0.05$). These findings are consistent with those of (Liu et al., 2019) in sunflower, (Hozayn et al., 2022) in the case of *V. faba*, and (Hozyayn, 2024) who concluded that plant growth was improved under salinity stress with the application of magnetized water. The enhancement is mostly seen to be caused by increased mobility of water, increased solubility of nutrients as well as increased efficiency of water uptake by plant roots.

Table 3. Effects of water treatments on vegetative characteristics of *V. faba* irrigated with five water types under saline conditions (7 dS m^{-1}).

Treatments	Plant height (cm)	Root length (cm)	Number of Leaves $plant^{-1}$	Nodules number	Nodule diameter (cm)	Mean
T0	24.45^{a}	35.54^{g}	19.12^{l}	10.51^{r}	0.39^{s}	18.82^{v}
T1	15.22^{b}	17.31^{h}	11.10^{m}	5.52^{s}	0.22^{s}	9.95^{c}
T2	28.76^{a}	38.54^{g}	21.13^{l}	15.54^{r}	0.49^{m}	20.89^{v}
T3	39.33^{d}	42.11^{i}	27.14^{n}	22.98^{t}	0.51^{n}	26.41^{h}
T4	48.56^{f}	57.81^{k}	32.43^{p}	28.31^{f}	5.17^{n}	34.28^{p}
Mean	31.26^{a}	38.26^{b}	22.18^{c}	16.57^{f}	3.94^{m}	—
LSD (0.05)	0.004	0.010	0.001	0.034	0.022	—

Mean values of different water types followed by different letters are expressively different at $P \leq 0.05$. Data represent the mean of 5 replicates ± SE. P. Het = plant height; R. L = root length; L. No = number of leaves; N. No = number of nodules; N. Di = nodule diameter.

Effect of mixed water (pottery and magnetic)

Pottery-treated and magnetized water together turned out to be the most effective treatment where the growth of plants was significantly improved at 7 dS m^{-1}. When *V. faba* plants grown in saline water ((7 dS m^{-1}) were irrigated with this mixed water, plant height and root length rose by about 58 per cent of individual pottery and magnetic water treatments. In addition, the parameters of the number of leaves and root nodulation were significantly improved and could exceed the control effects and the single-treatment effects (Table 3 and Figure 1, 2).

Such findings indicate that the mixed water treatment provided a more conducive growth environment since it combines the advantages of the two methods. Water became more efficient in absorbing nutrients and minerals, and water treated with pottery was more efficient in dissolving oxygen and being less toxic to ions (Hozayn et al., 2019). Moreover, pottery water can have a high concentration of some of the essential mineral elements; including calcium, magnesium and iron, which are washed off the pottery material and into plant nutrition.

Additionally, the water kept in pottery containers is likely to be kept cooler compared to normal water because of the evaporative heat loss especially in hot weather. This cooling action is also viable to facilitate favorable enzyme action and sustain major physiological functions. The effects of these conditions were observed in the experimental results in the form of increased nitrogen uptake and antioxidant activity. (Ben Hassen et al., 2020) also reported similar conclusions and showed that saline stress may be successfully handled to enhance the growth of plants. (Sutiyanti and Rachmawati, 2021) also observed significant improvements in rice growth following magnetic water treatment. Likewise, (Mohammed 2020) and (Mohammed and Aml, 2024) reported enhanced growth of *V. faba* and garlic irrigated with magnetized water under saline conditions.

Finally, Table 4 shows a positive correlation between water treatments and phenotypic traits of *V. faba*, further confirming the effectiveness of the applied water treatments in improving plant growth under salinity stress.

Chemical changes

Saline water (7 dS m^{-1}) treatment of *V. faba* caused severe changes in biochemical properties. Most of the chemical indicators were reduced significantly, and the action of the antioxidant enzyme catalase (CAT) and superoxide dismutase (SOD) were significantly elevated ($p \leq 0.01$). The results are in agreement with previous reports by (Gobade et al., 2024; Jahan et al., 2025) in soybean, as both studies reported the adverse impact of salinity on biochemical biomarkers and the corresponding activation of antioxidant defense.

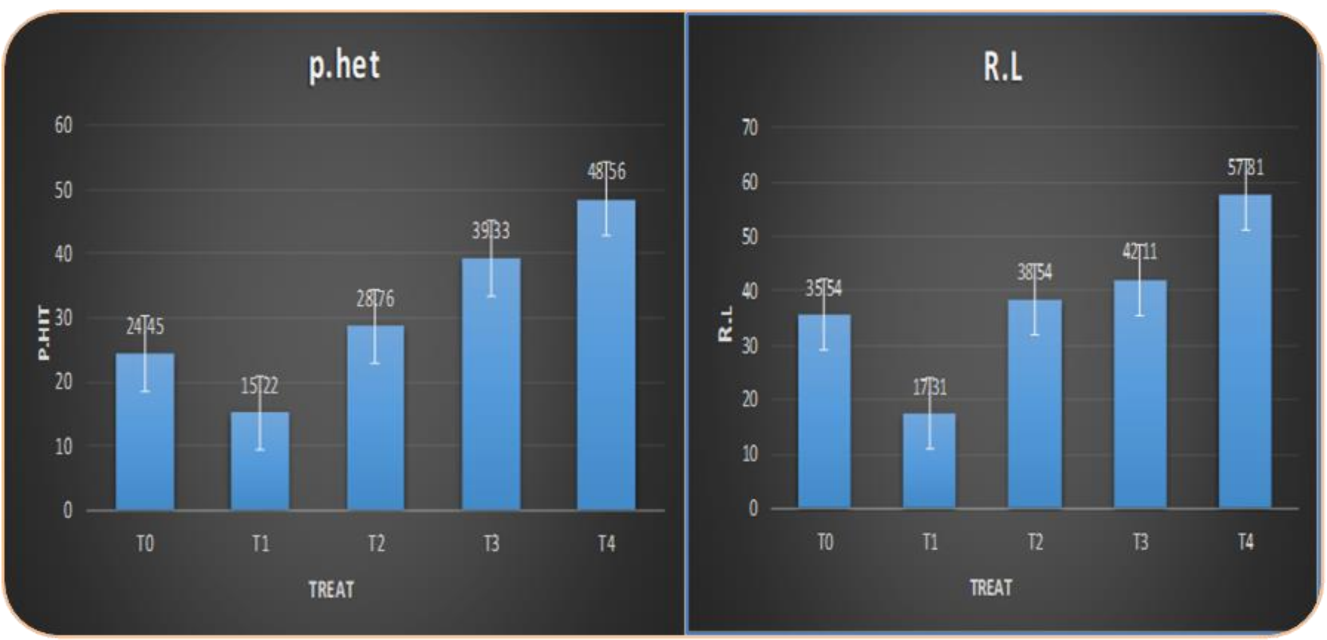

Figure 1. Effects of different water treatments on growth parameters of *V. faba* Plant height (PH) and root length (RL) under the following treatments: T0 = control, T1 = salinity, T2 = pottery water, T3 = magnetic water, and T4 = mixed pottery and magnetic water.

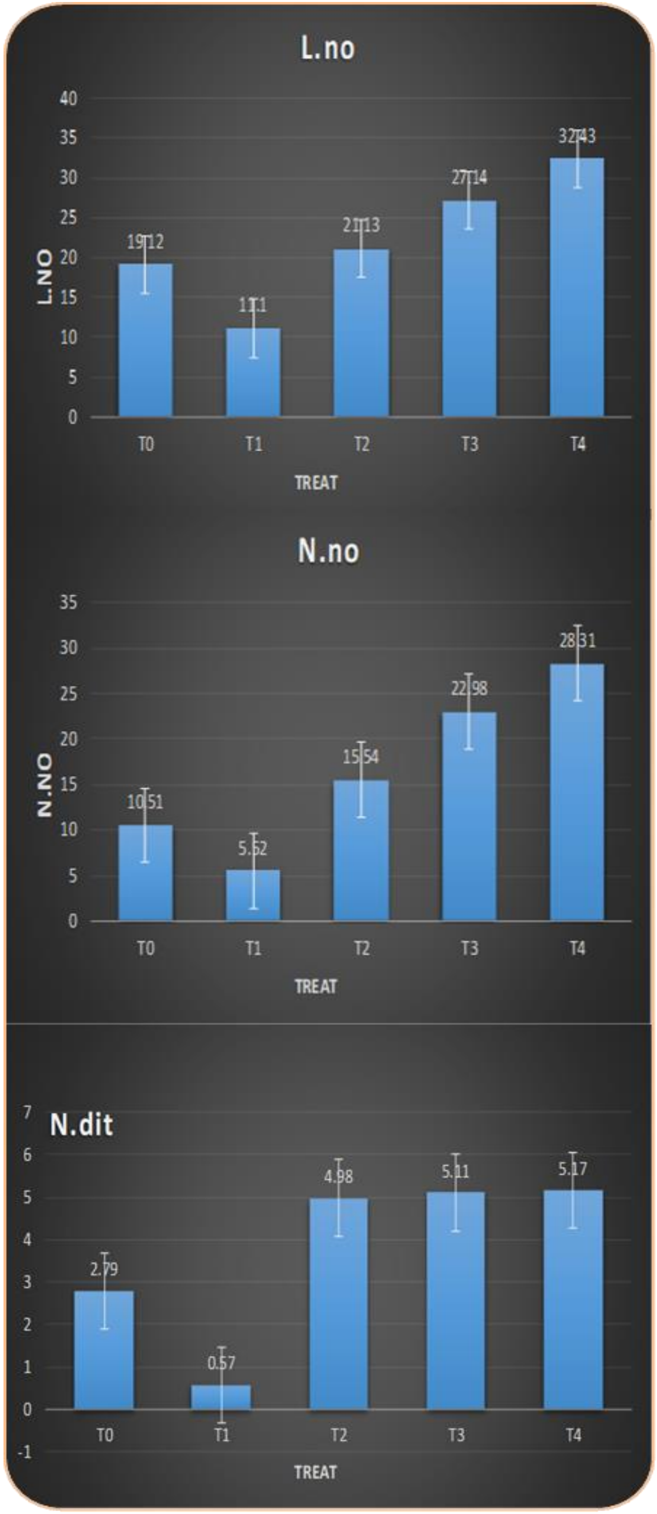

Figure 2. Effect of different water treatments on growth parameters of *V. faba* L. L. No. = number of leaves per plant; N. No. = number of nodules per plant; N. Dia. = nodule diameter. Treatments: T_0 = control, T_1 = salinity, T_2 = pottery water, T_3 = magnetic water, T_4 = combined pottery and magnetic water.

Salts in the soil change the osmotic conditions of the soil surrounding the plant roots, limiting nutrient absorption (Ying et al., 2018; Tong et al., 2024). In addition, salinity ions mostly the NaCl is taken up in excess resulting in the occurrence of ionic toxicity in plant tissues affecting the normal physiological processes. Such toxicity disrupts the absorption of nitrogen by destabilizing membranes and disrupting the absorption of important mineral nutrients like potassium (Mathios et al., 2024). Moreover, salinity inhibits ammonium to nitrate transformation in soil and hence decreases the availability of nitrogen, consequently reducing the soluble protein content.

Considering these mechanisms, (Badawy et al., 2017) found that the soluble and total protein decreased in *Brassica rapa* L. when the plants were subjected to saline environment. Equally, the current experiment had a soluble protein content reduced by 48 percent when exposed to salinity stress (Table 4 and Figure 3). This decrease can be explained by the reduced availability of nitrogen and lesser energy production in the cell due to the destruction of membranes as a result of salt stress. (Kala, 2015) also made similar observations in cluster bean plants.

The salinity stress also resulted in a large increase in the activity of antioxidant enzymes especially CAT and SOD because of the extreme build-up of reactive oxygen species (ROS) (Table 4 and figure 3). At the value of p 1 = 0.05, the CAT and SOD activities increased significantly. The same phenomenon has been described by (Mohammed et al., 2023) in wheat and (Carlos et al., 2025) in *Lycopersicon* spp. Another adaptive defense mechanism that also reduces the oxidative damage of cellular membranes and proteins is the upregulation of antioxidant enzymes (Fatima et al., 2024).

Interestingly, pottery water and magnetized water irrigation of *V. faba* under saline conditions led to a significant change in chemical indicators. The uptake of nitrogen and soluble protein content was high as compared to those that received saline water only. These results indicate that the water of pottery and that of magnetized water mitigated the negative impacts of salinity and promoted the efficiency of metabolism.

(Hamad et al., 2016), (Rahayu et al., 2021) and (Amal et al., 2021) reported supporting evidence as they noted higher CAT and SOD activities in maize, barley, and *V. faba* plants with pottery and magnetized water. Similarly, (Podleśna et al., 2019) found that biochemical properties of *V. faba* improved after the treatment with magnetized water (Table 4 and figure 3).

Table 4. Effects of water treatments on the chemical composition of *V. faba* under Salinity stress (7 dS m^{-1}).

Treatments	Soluble proteins ($mg\ g^{-1}$ FW)	Total chlorophyll ($mg\ g^{-1}$ FW)	CAT activity ($U\ min^{-1}\ g^{-1}$ FW)	SOD activity ($U\ min^{-1}\ g^{-1}$ FW)	Mean
T0	18.75^{a}	1.93^{e}	5.22^{v}	23.43^{f}	12.33^{c}
T1	5.32^{b}	0.59^{f}	13.88^{c}	53.08^{d}	18.21^{v}
T2	22.69^{d}	2.22^{g}	7.99^{m}	34.54^{v}	16.86^{b}
T3	26.74^{d}	3.14^{c}	10.65^{n}	44.85^{r}	21.34^{n}
T4	30.11^{d}	3.98^{d}	11.98^{n}	47.92^{r}	23.49^{n}
Mean	20.72^{a}	8.67^{b}	9.94^{b}	40.76^{k}	—
LSD	0.001	0.001	0.057	0.057	—

Mean values of different water types followed by different letters are expressively different at $P \leq 0.05$. Data represent the mean of 5 replicates ± SE. Sol Pro = soluble protein; T Chl = total chlorophyll; CAT = catalase enzyme; SOD = superoxide dismutase enzyme.

Besides, pottery water, and magnetized water, when used together, caused significant improvements in antioxidant enzyme activities relative to the application of salinity treatment used individually ($p \leq 0.05$). The CAT and SOD activities of 11.98 and 47.92 U min^{-1} mg^{-1} were achieved, respectively, when compared with 13.88 and 53.08 U min^{-1} mg^{-1} under salinity stress alone. It means that this reaction allows the enhancement of nitrogen metabolism and protein synthesis, subsequently increasing the metabolic rate and the creation of ROS and consequently, the stimulation of antioxidant enzyme activity (Table 4 and figure 3).

A massive decrease in total chlorophyll content ($p \leq 0.05$) was also exhibited by salinity stress, which resulted in values of 0.59 mg g^{-1} and 1.93 mg g^{-1} in the control and the stressed population, respectively. Saline ions are easily carried through the xylem to the aerial tissues in the process of transpiration, where they are deposited that interferes with the photosynthetic systems. Salinity stress lowers the CO_2 assimilation and increases the production of ROS that causes the damage of membranes and the loss of chlorophyll (Mohammed et al., 2023).

Treatment using pottery water, magnetized water, or a mixture of the two under saline conditions, however, attenuated the reduction of chlorophyll content. It was found that water treatments were positively associated with enhanced chemical properties and thus they were effective in relieving salt stress (Table 4 and figure 3). Better growth parameters and higher chlorophyll content were linked to increased uptake of nutrients especially calcium and magnesium, both of which, are necessary in chlorophyll biosynthesis.

Such results are in line with previous research. According to (Etimad et al., 2021), maize plants irrigated with magnetized water had better growth and chlorophyll content. Likewise, Marcelo et al., 2021) have recorded a 43 percent improvement in chlorophyll content of pepper plants which were irrigated with magnetically activated water. The improvement in photosynthetic efficiency and growth reactions in Tabasco pepper, radish, and maize in response to magnetic water treatment were also reported by (Ospina-Salazar et al., 2018).

Productivity

The outcome of this research shows that pottery water, magnetic water, and a combination of the two under saline conditions (7 dS m^{-1}) applied to *V. faba* worked tremendously in promoting plant productivity. The treatment that stood out as the most productive was the magnetic water which yielded 35% more than pottery water. Surprisingly, the technological advancement of pottery and magnetic water enhanced the productivity of plants significantly by increasing their productivity by 65% when compared to the single treatment.

Conclusion

The results of this experiment ensure that application of physical water, both pottery and magnetic water, have a positive effect on plant growth in saline stress. All vegetative and biochemical indicators improved, and it helped in the improved development of the plant. Interestingly, the synergistic effect of pottery and magnetic water had the strongest effects on the vegetative growth parameters such as the stem height, the root length, the amount and size of root nodules and the amount of leaf count. In addition, this mixture triggered the main antioxidant enzymes, which reduced the negative impacts of salinity. These findings highlight the possibility of the physical water treatments to be a sustainable and environmentally sound method in order to stimulate growth of plants in salty conditions.

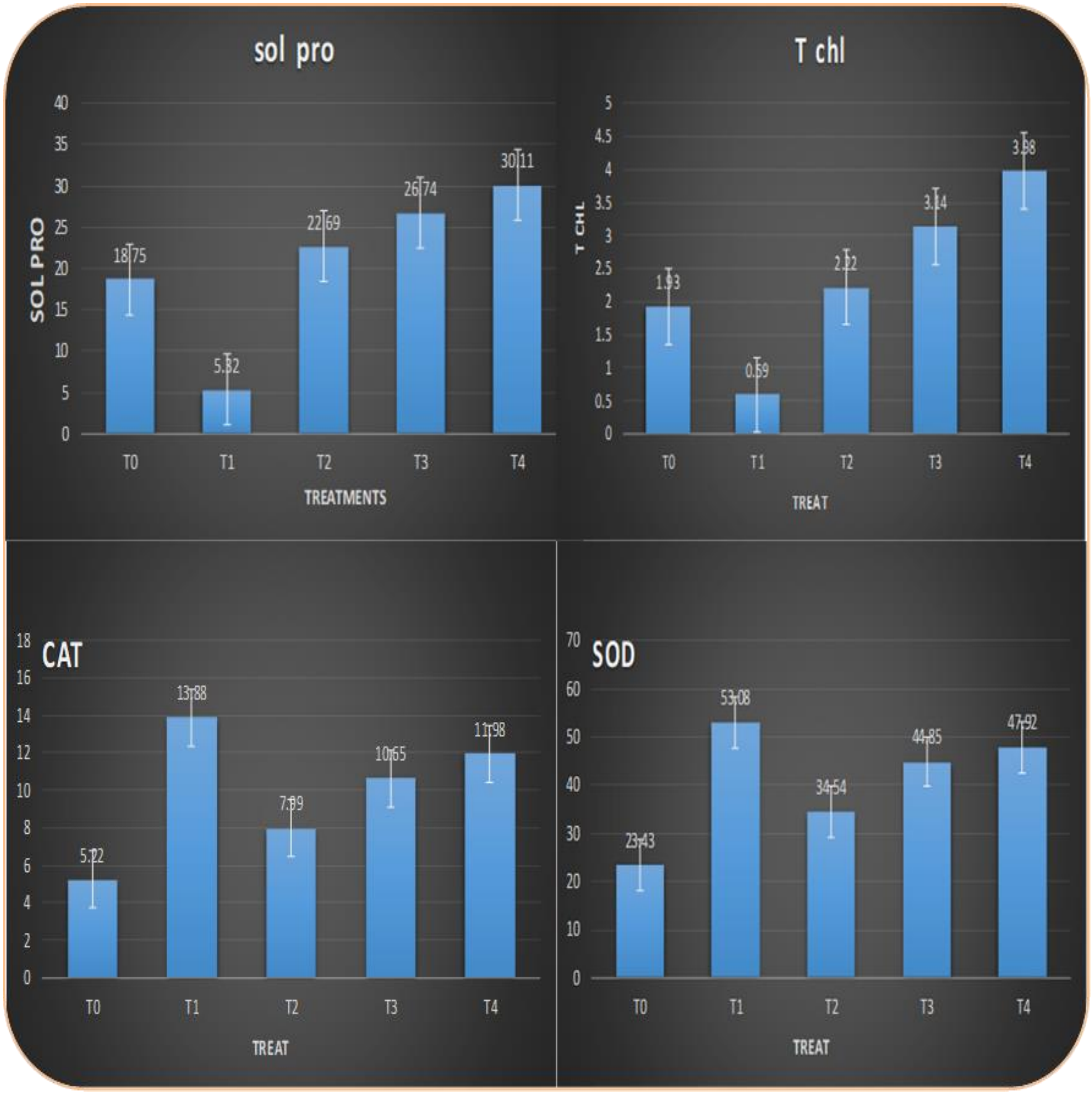

Figure 3. Effects of water treatments on biochemical parameters. Sol = soluble protein; Tchl = total chlorophyll; CAT = catalase; SOD = superoxide dismutase. Treatments: T0 = control, T1 = salinity, T2 = pottery water, T3 = magnetic water, T4 = combined pottery and magnetic water.

Authors' Contributions

Both authors jointly conceptualized and designed the study, analyzed the data, and drafted the manuscript. They provided critical guidance and constructive feedback, reviewed and approved the final version, and agreed to be accountable for the accuracy and integrity of the work.

Research Funding

This research did not receive any grant from funding agencies.

Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger

SDG 6: Clean Water and Sanitation

SDG 12: Responsible Consumption and Production

References

Amal, F., Magida, S., Yousif, O., 2021. Impact of magnetic water irrigation on germination and growth of barley (*Hordeum vulgare* L) and faba bean (*Vicia faba* L) plants. Masarat 10, 279-289.

Badawy, E., Hanafi, A., Eman, E., Ahmed, S., Lauraa, P., Hend, F., 2017. Effect of salinity, selenium and boron on chemical composition of *Brassica rapus* L. plant grown under sandy soil conditions. Plant Science 8, 26-40.

Bavei, V., Wldren, R., Teare, I., 2011. Rapid determination of free proline for water-stress studies. Plant and Soil 39, 205-207.

Ben Hassen, H., Hozayn, M., Elaoud, A., Attia Abdd El-monem, A., 2020. Inference of magnetized water impact on salt-stressed wheat. Arabian Journal for Science and Engineering 45(6), 4517-4529.

Bullo, N., Tileye, F., Kifle, D., Ermias, A., 2021. The study of morphological characteristics and statistics of the phenotypes and correlation in faba bean (*Vicia faba* L.) germplasm. Plant Breeding and Biotechnology 9, 139-163.

Carlos, A., José, L. Claudia M., Agraz, H., Román A. 2025. Salinity as an Inducer of Antioxidant Activity Exerted by Mangrove Species from Campeche, Mexico. Journal of Plant. 14, 800-812.

Etimad, A., Khitam, E., Eqbal, R., 2021. Effects of magnetic field treated water on some growth parameters of corn (*Zea mays*) plants. Journal of Biophysics 8, 267-280.

Fatima, A., Al Otaibi, A., Sameera, A., et al., 2024. The influence of salinity on plant growth and amendment strategies - A review. Journal of Sohag Agri-Science 9, 261-267.

Gobade, A., Arathi, S., Gijare, S., Pawar, D., Patil, A.S., 2024. Evaluating salt tolerance in soybean core collection: Germination response under salinity stress. Genetic Resources and Crop Evolution 71, 21-38.

Gong, H., Zhu, K., Zhang, C., 2005. Silicon elevates oxidative damage of wheat plant in pots under drought. Plant Science 109, 313-321.

Hamad, A., Gauwra, Z., Momta, Z., Fenu, P., Han, A., 2016. High salinity induced oxidative stress and antioxidant response in maize seedling organs. Frontiers in Plant Science 7, 276-285.

Han, G., Youcai, Q., Rong, Y., 2018. Enhanced plant growth promoting role of mPEG-PLGA-based nanoparticles as an activator protein PeaT1 carrier in wheat (*Triticum aestivum* L.). Journal of Chemical Technology and Biotechnology 93, 3143-3151.

Hande, E., Arabaci, G., 2016. Determination of SOD, POD, PPO, and CAT enzyme activities in *Rumex obtusifolius* L. Annual Research and Review in Biology 11, 1-7.

Hossain, A., 2023. Effect of potting media and pot size on yield and fruit quality attributes of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*). International Journal of Horticultural Science and Technology 10, 141-148.

Hozayn, M., Abd El-Monem, A., El-Mahdy, A., 2022. Alleviation of salinity stress in germination, seedling vigor, growth, physiochemical, yield and nutritional value of chickpea (*Cicer arietinum* L.) using magnetic technology. Egyptian Journal of Chemistry 65, 1317-1331.

Hozayn, M., Amal, A., Abd El-Monem, A., Sara, S., Darwish, M., 2024. Magnetic technology for mitigation of salinity water stress on faba bean. Egyptian Journal of Chemistry 67, 85-95.

Hozayn, M., Ismail, S.M., Abd El-Monem, A., Darwish, M., 2019. Magnetically treated brackish water: A new approach for mitigation of salinity stress on sunflower productivity and soil properties under South Sinai Region, Egypt. Alexandria Science Exchange Journal 40, 441-446.

Huang, P.V, Vien, N.L., Phi, N.T.L., 2016. Resistant starch improvement of rice starches under a combination of acid and heat-moisture treatments. Food Chemistry 191, 67-73.

Jahan, N., Sabim, M.M.R., Siddikee, M.A., Hossain, I., Zahid, M.M.H., Mukta, T.A., Al Kafi, A., 2025. Effect of salinity on growth, yield characteristics and nodulation in soybean (*Glycine max* L.). Journal of Agricultural Sciences and Engineering 7(1), 1-10.

Kala, S., 2015. Protein profile of cluster bean (*Cyamopsis tetragonoloba* Taub) genotype under salinity stress. Journal of Global Engineering Technology and Sciences 2, 19-23.

Liu, X., Zhu, H., Meng, S., Bi, S., Zhang, Y., Wang, H., Song, C., Ma, F., 2019. The effects of magnetic treatment of irrigation water on seedling growth, photosynthetic capacity and nutrient contents of *Populus euromericana* under NaCl stress. Acta Physiologiae Plantarum 41, 1-13.

Marcelo, L., Roberto, R., Cássio, D., Castro, S., 2021. Application of magnetically treated water during initial growth of bell pepper seedlings. IDESIA 39, 67-77.

Mathios, J., Victor, T., Alpaslan, E., Kitio, P., 2024. Effects of salt stress on plant growth, nutrient partitioning, chlorophyll content, leaf relative water content, accumulation of osmotic and antioxidant compounds in pepper (*Capsicum annuum* L.) cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 48, 1-18.

Merga, B., Haji, J., Yildiz, F., 2019. Economic importance of chickpea: Production, value, and world trade. Cogent Food and Agriculture 5, 1615718.

Mohammed, A., Aml, M., 2024. Magnetized water as an eco-friendly irrigation alternative ameliorates cytogenetic impairments in *Vicia faba* under two fertilizers. Egyptian Journal of Genetics and Cytology 54.

Mohammed, A., Ayman, S., Fahed, A., 2023. Effect of salinity stress on oxidative stress parameters and the activity of antioxidant enzymes in eight durum wheat genotypes. Iraqi Journal of Science 64, 3882-3893.

Mohammed, E., 2020. Evaluation of drip irrigation systems for maximizing water use efficacy for garlic in desert soil in Al-Sadat area, Egypt. Plant Archives 20, 9211-9220.

Mohammed, J., Minghzing, D., Caixia, Z., et al., 2025. Antioxidant defense system in plants: Reactive oxygen species production, signaling, and scavenging during abiotic stress-induced oxidative damage. Horticulturae 11, 477.

Mohammed, T., Imran, K., Muhammed, U., et al., 2025. The critical role of nitrogen in plants facing salinity stress and future prospective. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 51, 133-147.

Musa, U., Hassan, U., 2016. Leaf area determination for maize (*Zea mays* L.), okra (*Abelmoschus esculentus* L.), and cowpea (*Vigna unguiculata* L.) using linear measurements. Journal of Biology, Agriculture and Healthcare 6, 104-111.

Nusrat, J., Mostafizur, R., Ashaduzzaman, S., et al., 2025. Effect of salinity on growth, yield characteristics and nodulation in soybean (*Glycine max* L.). Journal of Agricultural Science and Engineering 7, 1-10.

Ospina-Salazar, D., Benavides-Bolanos, Z., Zuniga, E., Munoz, P., 2018. Photosynthesis and biomass yield in Tabasco pepper, radish and maize subjected to magnetically treated water. Corpoica Ciencia y Tecnologia Agropecuaria 9, 307-321.

Padilla, F., Sánche, H., 2021. Clay fire and mostly water: Understanding the importance of water resources in pottery workshops in ancient Iberia by integrating ethnoarchaeological, experimental, and archaeological research. Ethnoarchaeology 13, 33-58.

Podleśna, A., Bojarszczuk, J., Podleśny, J., 2019. Effect of pre-sowing magnetic field treatment on some biochemical and physiological processes in faba bean (*Vicia faba* L. spp. minor). Journal of Plant Growth Regulation 38, 1153-1160.

Rahayu, H., Aktavia, H., Komariah, S., 2021. Water efficiency and eggplant (*Solanum melongena* L.) growth with size pottery irrigation in Alfisols and Entisols. IOP Conference Series: Earth and Environmental Science 824, 012036.

Rahayu, R., Aktavia, H., Rivaldi, A., Komariah, K., 2022. The effect of pottery material composition as subsurface irrigation on the growth of chili (*Capsicum annuum* L.) in Alfisols and Entisols. Environment and Ecology 1, 120-132.

Samoona, S., Qudsia, N., Ifra, S., Raheela, N., Sajida, A., Noor, U., Muhammad, R., Muhammad, U., 2023. Soil salinity hinders plant growth and development and its remediation: A review. Journal of Agricultural Research 61, 189-200.

Shanko, D., Jatena, G., Debla, A., 2017. Effect of salinity on chickpea plant (*Cicer arietinum* L.) landraces during germination stage. Biochemistry and Molecular Biology Journal 3, 214-219.

Sutiyanti, E., Rachmawati, D., 2021. The effect of magnetized seawater on physiological and biochemical properties of different rice cultivars. Biodiversitas 22, 3083-3091.

Tong, H., Yingji, A., Pergrvi, A., et al., 2024. Soil and plant nutrition of agronomy. Agronomy 14, 299.

Vaskina, I., Roi, L., Plyatsuk, R., Vaskina, O., Yakhnenk, O. 2020. Study of the magnetic water treatment mechanism. Journal of Ecological Engineering 21,

251-260.
Ying, Z., Nannyu, T., Lijin, H., et al., 2018. Effect of salt stress on plant growth, antioxidant capacity, glandular trichome density and volatile exudates of Scizonepeta tenuifolia Briq. International Journal of Molecular Sciences 19, 252.
Zhou, Y., Tang, N., Huang, L., Zhao, Y., Tang, X., Wang, K., 2018. Effects of salt stress on plant growth, antioxidant capacity, glandular trichome density, and volatile exudates of *Schizonepeta tenuifolia* Briq. International journal of molecular sciences 19(1), 252.