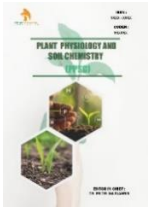
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2805-5063 (Online)
CODEN: PPSCCU

Plant Physiology and Soil Chemistry (PPSC)

DOI: http://doi.org/10.26480/ppsc.02.2025.84.92



RESEARCH ARTICLE

EFFECT OF PRE-SOWING SEEDS' MAGNETIC TREATMENT AND CHITOSAN ON THE SOIL FERTILITY AND NIGELLA (*NIGELLA SATIVA* L.) QUALITY AND PRODUCTIVITY

Khaled A. H. Shaban[a], Mohamed I. Mohaseb[a,*], Engy A. Soltan[b], Nevien M. Eid[b]

[a] Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt
[b] Medicinal and Aromatic Plant Research Department, Horticulture Research Institute, Agricultural Research Centre, Cairo, Egypt.
**Corresponding Author Email: mohasebmohamed@yahoo.com*

ARTICLE DETAILS

Article History:

Received 09 March 2024
Revised 15 April 2024
Accepted 02 May 2024
Available online 13 June 2025

ABSTRACT

Two field experiments were carried out to study the single and combined effect of pre-sowing magnetic treatment of seeds for different time intervals with and without soaking seeds in the chitosan solution on some parameters of the soil fertility and on the productivity of Nigella (Nigella sativa L.) under saline calcareous soil conditions. The experiments were set in the Central Laboratory of the Agricultural Research Center (El-Bossily Protected Cultivation Experimental farm, the Northern Coastline of Nile Delta, El-Beheira Governorate), Egypt, in a split plot design with six replicates during the two successive winter seasons of 2021/ 2022 and 2022/ 2023 respectively. The main factor was the type of seed treatment (magnetic or soaking) before sowing and the sub-factor was the time (min) of treatment. The results indicated revealed that the Magnetization + Soaking in chitosan has decreased the EC (dS m-1) and increased the soil content of available macro-micronutrients contents compared to other treatments. Same treatment has also resulted in the maximum mean values obtained for the plant height (cm), number of branches/plant, number of capsules/plant, weight of seeds/plant and seeds' yield (kg/ha). The macro-micronutrients' concentrations in the Nigella seeds were also increased. Increasing the time interval of the magnetic treatment has increased the values of all plant parameters. Also, values of the protein (%), oil and chlorophyll contents were enhanced by pre-sowing seeds magnetization and soaking in the chitosan, while the proline contents in seeds were lower than the control.

KEYWORDS

Calcareous Soil, Magnetism, Medicinal Plants, Seed Priming.

1. INTRODUCTION

Plant nutrition especially medicinal and aromatic plants under the saline calcareous soil conditions is depending on the nutrients' availability that is restricted by some land utilization problems such as crusting of the surface soil layers, cemented condition of the subsoil layers and the low organic matter (OM) content. Some of the eco-friendly and safe strategies to improve the crops' yield and quality for sustainable agriculture include magnetic treatment of seeds before sowing and application of biofertilizers like the chitosan (Chandrkachang, 2002). Pre-sowing magnetic treatment of seeds by their exposure to a magnetic field (MF) may be preferred compared to the biological and chemical stimulators because it is free of toxic residues. It is an effective method can improve the post-germination of seeds, stress tolerance, and crop production. Action mechanism of the exposure to a MF may induce enzyme changes and regulates the expression of different enzymes and the stimulation of proteins.

Magnetic field bio-stimulation plays a significant role in enhancing the germination of seeds and increasing the metabolic rate. The magnetic field's impact on sunflower seeds subjected to MF at varying intensity (millitesla, mT) for different exposure times was examined. The MF 50 mT for 45 min treated seeds led to increase of bio-stimulation on pre-sown sunflower seeds, growth parameters of seedlings (biomass, root and shoot length, fresh and dry weight of roots, shoots, leaf, and height of plants), and antioxidant activities (Bukhari et al., 2021). Treatment by MF controls the content of indol acetic acid (IAA) in the seeds and affects its action mechanism. It is especially important in the beginning phase of plant development because the main role of these compounds is stimulation of plant growth by enhancement of its elongation growth.

The increase in IAA content may be caused by hydrolysis of IAA conjugates, whereas the level of reduction is the result of irreversible conjugation or oxidative hormone degradation (Jakubowska, 2004).Treating the seeds with a MF increased the activity of amylolytic enzymes in seeds and seedlings of plants after the period from 120 to 168 h after sowing seeds. The activity of the enzymes was increasing over time, reaching the highest value after 168 h from sowing (Podleśna et al., 2019). The magnetic treatment of Nigella sativa seeds in at 25 and 50 mT intensity MF for 0, 30, 60 and 120 min significantly increased the percentage and germination rate root length, highest numbers of capsules perhighest numbers of capsules/plant and dry weight of the plant in comparison to the control (Poorakhar et al., 2010).The magnetic treatment of seeds for 15 min has increased the seeds yield by of 69% = 605.1 kg/ha compared with the control (without MF) of 187.9 kg/ha (Marghayizadeh et al., 2014).

Chitosan is an amino polysaccharide obtained by the alkaline deacetylation of the chitin extracted from the exoskeleton of crustaceans such as shrimps and crabs, or cell walls of some fungi. Chitosan is nontoxic, biodegradable and friendly to environment. It has been recognized to improve crop production due to their bioactivities to plants, which included stimulating growth of plants and seeds (Chandrkachang, 2002). The effect mechanism of chitosan on plant growth may be attributed to an

Quick Response Code	Access this article online	
	Website: www.ppsc.org.my	**DOI:** 10.26480/ppsc.02.2025.84.92

Cite The Article: Khaled A. H. Shaban, Mohamed I. Mohaseb , Engy A. Soltan, Nevien M. Eid (2025). Effect of Pre-Sowing Seeds' Magnetic Treatment and Chitosan on The Soil Fertility and Nigella (Nigella Sativa L.) Quality and Productivity. *Plant Physiology and Soil Chemistry, 5(2): 84-92.*

increase in the availability and uptake of water and essential nutrients through adjusting cell osmotic pressure, and reducing the accumulation of harmful free radicals (ROS) by increasing antioxidants and enzyme activities. Chitosan solution spraying increased the leaf proline content and the chlorophyll content (Malekpoor et al., 2016). Foliar spraying of chitosan has been shown to stimulate vegetative growth and improve yield and quality of several crops (Cheung et al., 2015). A group researcher has revealed that leaf proline content varied affected by foliar applications (Mohamed et al., 2018). The foliar application of chitosan, especially at 0.4 g/l, in most cases resulted in a significant increase in basil plant growth parameters under normal or stressed conditions and improved all plant growth parameters compared to untreated control plants.

Nigella (*Nigella sativa* L.) has been approved in different medicinal systems for its enormous medicinal properties. Nigella seeds have been widely used in unani, ayurveda, siddha and other ethno-medicine systems worldwide. It is pharma-cologically active as anti-tumour, anti-diabetic, cardioprotective, gastro protective, antiasthmatic, nephroprotective, hepatoprotective, anti-inflmmatory, immuno modulatory, neuro-protective, anti-convulsant, anxiolytic, antioxidant, anti-nociceptive, anti-oxytocic, contraceptive, abortifacient, anti-implantation, diuretic, anti-urolithiatic, anti-spasmolytic, anti-bacterial, anti-fungal, anti-schistosomiasis and anthelmintic (Giridhat et al., 2017). The black cumin is a highly valued nutraceutical herb with a wide array of health benefits, has attracted growing interest from health-conscious individuals, the scientific community, and pharmaceutical industries.

The pleiotropic pharmacological effects of black cumin, and its main bioactive component thymo-quinone (TQ), have been manifested by their ability to attenuate oxidative stress and inflammation, and to promote immunity, cell survival, and energy metabolism, which underlie diverse health benefits, including protection against metabolic, cardiovascular, digestive, hepatic, renal, respiratory, reproductive, and neurological disorders, cancer, and so on. Furthermore, black cumin acts as an antidote, mitigating various toxicities and drug-induced side effects (Abdul et al., 2021). This study aims to improve the growth and productivity of the *Nigella sativa* plant in the calcareous saline soil by the magnetic treatment of seeds before cultivation either as an individual treatment or combined with soaking in a chitosan solution.

2. Materials and Methods

2.1 The experimental soil area and characteristics

Two field experiments were carried out in El-Bossily Protected Cultivation Experimental farm (3 m above the sea level, 31.40°N latitude - 30.40°E longitude), Central Laboratory (Agricultural Research Center) at the Northern Coastal of the Nile Delta, El-Beheira Governorate, Egypt. Some of the main soil properties were determined before planting by the recommended methods and recorded in Table (1) (Klute, 1986; Page et al., 1982). In both winter seasons of 2021/2022 and 2022/2023, each experiment was laied out in a split plot design with six replicates. Each plot area was 5×3 m² divided into 65 cm spaced rows. The main factor was the type of seed treatment (magnetic or soaking) before sowing and the sub-factor was the time (min) of treatment.

Table 1: Physical and chemical properties of the soil under study before Nigella sativa planting

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	OM (%)	$CaCO_3$ (%)
3.17	75.36	8.57	12.60	Sandy loam	0.69	13.22

pH (1:2:5)	EC (dS/m)	Cations (meq/L)				Anions (meq/L)		
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
8.12	7.60	7.30	15.20	52.72	0.78	8.34	44.85	22.81

Available nutrients (mg/kg)					
Macro-nutrients			Micro-nutrients		
N	P	K	Fe	Mn	Zn
32.75	5.20	185.00	3.66	9.44	0.63

The experimental area was one feddan = 4200 m² = 0.42 ha divided into three parts:

- The 1st part was assigned for the magnetically treated seeds before sowing for different magnetization time intervals (0, 5, 10, 20 min),
- The 2nd part was assigned for soaked seeds in the chitosan solution for different time intervals (0, 5, 10, 20 min)
- The 3rd parts was assigned for a combined treatment in which the seeds before sowing were soaked in the chitosan and magnetically treated for different times.

2.2 Treatment Of Seeds Before Sowing

Seeds of the Nigella sativa were placed inside the magnetic device for 0, 10, 15 and 20 min. The magnetic device in Figure 1 consists of an insultated metallic tube 70 cm length, 2 inch diameter, 1.5 tesla magnetic field (MF) strength. The same device was used to magnetize water used to prepare the foliar sprayed chitosan solution. Another amount of the Nigella sativa seeds were soaked in a diluted chitosan solution (1.2 L chitosan in 200 L water). After 45 days from sowing, as a part of the fertilization program of the cultivated plant, a similar chitosan solution (200 L) was prepared using a magnetized water was foliar applied on the plants and the whole soil area as an activation dose to activate the plant growth.

Figure 1: Device used for the magnetic treatment

2.3 Sowing, fertilization, harvesting and analysis the Nigella sativa samples

Sowing the Nigella seeds (*Nigella sativa* L.) was completed on the 15th of November 2021 and 2022 respectively. About 2-3 seeds were sown in 3 cm depth holes with 25 cm spacing. Plants in each hole were thinned to one plant at 25 days after sowing. The recommended farming practices were performed before planting and during the cultivation season under drip irrigation system. The soil was fertilized during tillage before planting by the super phosphate (15.5% P_2O_5, application rate 714.3 kg ha^{-1}). Each of the urea (46% N, application rate 238.1 kg ha^{-1}) and potassium sulphate (48% K_2O, application rate 178.6 kg ha^{-1}) were applied on three equals doses after 25, 45 and 65 days from planting.

Plant samples were taken after 70 days from sowing for determination of some vegetative growth parameters and chlorophyll contents. At the harvest stage on the 25th May 2022 and 2023, ten random plants were sampled from each plot to determin the parameters: plant height (cm), No. of branches/plant, No. of capsule/plant, seeds wt. (g)/plant and seeds yield (kg/ha). The Nigella herb samples were oven dried at 70°C for 48 hours. Samples (0.5 g) were acid digested by sulphuric/perchloric acids mixture (Chapman and Pratt, 1978). Concentrations of the nutrients in seeds were estimated as follows: Nitrogen N (micro-Kjeldahl method), phosphorus P (colorimetrically at 660 nm using the $SnCl_2$ phosphomolibdic-sulforic acid method), potassium K (flame photometer), Fe, Mn, and Zn (Atomic Absorption - GBC 932 model) (Page et al., 1982). The oil (%) was estimated by the Soxhlet apparatus using petroleum ether as a solvent (AOAC., 1980). The photo-synthetic pigments (total chlorophyll) were estimated in the fresh leaves while the total carbohydrates were estimated in the dry leaves (Witham et al., 1971; Dubois et al., 1956). Proline content was estimated according to (Bates et al., 1973).

2.4 Statistical analysis

Data obtained from both seasons were tabulated and statistically analyzed by the MSTAT-C software, as the means of data were compared using the least significant difference (L.S.D.) test at the 5% significance level (Mead et al., 1993).

3. Results

3.1 Effect of the pre-sowing seed magnetization and/or soaking in the chitosan solution on some soil properties

3.1.1 Soil pH

The experimental soil is slightly to moderately alkaline (pH 8.07-7.90). The soil sprayed by the chitosan showed a decreasing in the pH value, which tends to increase slightly after the leaching by the irrigation. Results in Table (2) show that the soil pH has decreased from a value 8.07 to 7.90 under the effect of the combined treatment (Magnetization+Soaking). This positive effect is more pronounced in the surface layers of soil. However, this variation is temporary only affected by the treatments and cultivation practices. This is because the buffering action of the soil will re-equilibrate the soil system to its natural equilibrium pH after the residual effect of the cultivation season terminates. The reduction in soil pH may be related to the residual active organic acids and compounds dissolved in the chitosan solution and reached the top layer of soil. Chitosan foliar application had been shown an ability to lower the soil pH. Its effect may be attributed to an increase in numbers of microbial populations in soil, and the transformation of inorganic forms into organic forms of nutrients that are absorbed easily by plant roots (Ahmed et al., 2024). A researcher had found decreased values of soil pH by magnetized seeds combined with 75% of the recommended doses of N-P-K fertilizers (Abou El-Yazied, 2012). Some researchr reported decrease pH value (7.85 and 7.82) for magnetized treatments for 10 and 15 min, respectively (Fatth and Esmaeil, 2022). Also, El-Sonbaty showed that the application of magnetic water had led to a decreased soil pH than soil not irrigated by magnetic water (El-Sonbaty, 2020). The decrease of soil pH may be due to the release of free H^+ ions in the soil solution. Also, leaching salts from soil profile and adsorb H^+ ions instead of the other cations on clay and organic fractions, may lead to a decrease in the pH of the studied soils during the season of the study.

3.1.2 Soil salinity (EC, dSm^{-1}).

Data presented in Table (2) show that the combined treatment (Magnetization+Soaking) also decreased the EC (dS/m) compared other treatments but not significantly. The chitosan spray and the interaction between magnetic treatment and chitosan have significantly decreased the soil salinity under the present study conditions. The relative decreases of the mean soil salinity values was by 28.52% for soil of the magnetic treatment; 36.54% for soil of the chitosan treatment, and by 37.14% for soil of the combined treatment (Magnetization+Soaking) compared with control without magnetic treament. Magnetized water applied to salty soil down the salt crystals and helps in faster leaching of salts. The magnetized treatment was decrease of soil salinity was from 7.3 to 1.08 dSm^{-1}. Magnetized water may change the distribution of water and salt in the salinized soil, increase the water holding capacity and salt leaching from soil, and reduce the soil salt contents in the soil profile (Zhou et al., 2021). This may be attributed to a reduction in the viscosity of saline soil solution as a result of breaking water clusters in smaller sizes that lead to easier water penetration through the soil and faster salt washing process. Magnetic treatment of seeds has decrease of the salt stress on soil (Radhakrishnan, 2019). This change hydrogen bonds between water molecules and rebuilt them in hexagonal structure consequently increased the leachability of the soluble salts and probably destroyed the big salts crystals (Abd –Elrahman and Shalaby 2017). On another hand, a group researchers has reported that the application of chitosan on soil could decrease the soil salinity compared with untreated (Elsaka et al., 2018).

3.2 Available nutrients' content in soil

Table (2) shows that the increase of the N, P and K macronutrients' available contents in soil treated with chitosan combined with magnetic treatment compared with other treatments. There was a significant increase in the N and K available in soil while the P variation was not significant due to the soaking treatment. The effect of magnetization on the N, P and K availability in soil was not significant. The interaction effect between the chitosan and magnetization times on N and P was significant and P was no significant. On the other hand, the increase of magnetized times has led to increased macronutrients. The relative increases of mean values for N, P and K contents in soil were 9.56% for N, 17.10% for P and 2.67% for K, respectively, as affected by magnetic different times compared to those without magnetic treatment.

Table 2: Soil pH, EC and available of macro-micronutrients contents in soil after Nigella sativa harvest (mean two seasons)

Treatment type	Time (min)	pH (1: 2.5)	EC (dSm^{-1})	Macronutrients (mg/kg)			Micronutrients (mg/kg)		
				N	P	K	Fe	Mn	Zn
Magnetization	0	8.07	5.33	36.49	6.14	187.30	3.75	10.47	0.65
	5	8.05	4.20	38.28	6.85	188.54	3.99	10.88	0.67
	10	8.03	4.00	40.11	7.13	192.00	4.03	10.96	0.69
	15	8.01	3.85	40.32	7.23	193.29	4.09	11.23	0.73
	20	8.00	3.20	41.20	7.56	195.39	4.15	11.50	0.77
Mean		----	4.12	39.28	6.98	191.30	4.00	11.01	0.70
Soaking	0	8.05	5.20	38.40	6.50	188.40	3.87	10.95	0.69
	5	8.03	4.00	40.66	7.10	193.20	4.05	11.23	0.72
	10	8.01	3.54	43.20	7.55	195.39	4.15	11.54	0.76
	15	7.98	3.00	46.30	7.65	197.48	4.23	11.63	0.78
	20	7.95	2.66	48.30	7.76	198.44	4.39	11.97	0.79
Mean		----	3.68	43.37	7.31	194.58	4.14	11.46	0.75
Magnetization + Soaking	0	8.04	4.20	40.33	7.04	190.53	3.88	11.04	0.71
	5	8.02	3.55	43.60	7.23	193.78	4.12	11.75	0.74
	10	7.96	2.65	47.30	7.65	198.50	4.22	11.95	0.79
	15	7.92	2.25	48.20	7.73	201.38	4.34	12.14	0.82
	20	7.90	2.10	50.30	7.85	206.00	4.49	12.43	0.83
Mean		----	2.95	45.95	7.50	198.04	4.21	11.86	0.78
$LSD_{5\%}$ (Treatment)		---	**0.54**	**1.31**	**ns**	**1.10**	**ns**	**ns**	**0.016**
$LSD_{5\%}$ (Time)		---	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
Interaction		---	***	***	**ns**	***	**ns**	**ns**	***

The relative increases of mean values were 16.20%, 15.69% and 4.10% for N, P and K available in soil treated with chitosan combined with magnetic different time compared to those without magnetic treatment. As well as, the relative of mean values for available N, P and K contents in soil were 17.41%, 8.24% and 4.93%, respectively, as affected with chitosan plus magnetic different times compared to without magnetic treatment. This result may be due to more availability for the nutrients in the soil by lowering soil pH value through yielding intermediate organic acid as well as, increasing the activity of soil organisms to liberate more nutrients from the unavailable reserves that led to increased available nutrients.

The effect of chitosan application on nutrients contents in soil led to increase in the mineral content in soil, which may be due to being associated with its chelating tendency for nutrients along with its impact on physicochemical and biological properties of soil. The increase of available macronutrients (N, P and K) in soil as affected application of chitosan compared with control (Ahmed et al., 2024). Soil treated with magnetic treatment was increase of available soil N, K and P when compared with the control (non-magnetized) (Abedinpour and Rohani, 2017). The significant increase of available N, P and K contents in soil as affected with magnetic treatment time. The magnetic seed treatment increased the amount of microbial content of the soils such as nitrogen-fixation bacteria; this increase in microorganisms may improve the availability of elements in the soil (Shaban et al., 2023).

The maximum mean values of available micronutrients (Fe, Mn and Zn) contents in soil in Table (2) affected by treatments showed that there is a significant variation of Zn available in the soil treated with all treatments, while the Fe and Mn variation was not significant. The effect of magnetic treatment different times on (Fe, Mn and Zn) contents in soil was not significant, while the interaction between magnetic times and treatments were significant of Zn but Fe and Mn were not significant.

The relative increases of soil available contents' mean values were 8.55% for Fe, 6.40% for Mn and 10.77% for Zn, as affected with pre-sowing seeds magnetic treatment different time compared to the corresponding values without magnetisation. Also, the relative increases of mean values were 8.79% for Fe, 5.84% for Mn and 10.14% for Zn contents in soil treated with soaking in chitosan application combined different magnetic time compared without magnetic treatment . As well as , the relative increases of mean values Fe, Mn and Zn contents in soil treated with chitosan combined magnetic filed plus different time magnetic treatment were 10.57%, 9.33% and 12.68% for Fe, Mn and Zn, respectively, compared to treatments without magnetic treatment. Generally, it was could be seen that the soil available Fe, Mn and Zn in surface layer (0 - 30 cm) can arranged the following order as affected all treatments :

Soaking in chitosan + magnetic treatment > soaking in chitosan > magnetic treatment for Fe. Soaking in chitosan + magnetic > magnetic treatment > soaking in chitosan for Mn and Zn. These results are in agreement by who mentioned that the increase of values available Fe, Mn and Zn contents in soil as a result of the chitosan application (Ahmed et al., 2024). A group researcher had mentioned that foliar chitosan application can increase the plant nutrients in soil to maximize the growth and yield (Mahmod et al., 2022). Some researcher have reported that the soil available concentration of the N, P and K macronutrients and micronutrients (Fe, Mn and Zn) were significantly increased by increasing the magnetization time (Abd El-Fatth and Esmaeil, 2022). A group researchers found that the seed magnetic treatment had increased the amount of microbial content of the soils such as nitrogen-fixation bacteria, this increases the microorganisms and may improve the availability of elements in the soil for plant uptake (Ratushnyak et al., 2008).

3.3 Effect of pre-sowing seeds magnetic treatment and soaking seeds in chitosan on yield and yield components.

Data presented in Table (3) show that the increase of Plant height (cm), No. of branches /plant, No. of capsules/plant, weight of seeds/plant and weight of seeds kg/ha, respectively, with increasing of magnetic treatment times. The maximum mean values for Plant height (cm), No. of branches /plant, No. of capsules/plant, weight of seeds/plant and weight of seeds kg/ha) respectively as affected by soaking in chitosan plus magnetic treatment for different times compared with other treatments. The Effect of all treatments on *Nigella sativa* L. compounded were significant except weight of seeds kg/ha) was no significant. Also, the pre-sowing seeds magnetic treatment different times were significant on Plant height (cm), No. of branches/plant, No. of capsules/plant, weight of seeds/plant and weight of seeds kg/ha) respectively.

Table 3: Effect of the Magnetization and soaking treatments on the Nigella sativa yield (kg/ha) and some yield component

Treatment type	Time (min)	Plant height (cm)	No. Breanches /plant	No. of capsules/plant	Wt of seeds/plant (g)	Seeds yield (kg/ha)
Magnetization	0	48.90	5.98	17.88	6.90	489.40
	5	55.87	6.75	20.64	7.55	572.98
	10	60.74	9.70	25.60	9.66	643.62
	15	64.80	12.90	29.75	10.85	688.10
	20	70.65	13.88	32.00	12.65	742.86
Mean		60.19	9.84	25.17	9.52	627.38
Soaking	0	52.10	6.12	18.00	7.85	516.43
	5	68.90	6.86	22.76	10.66	656.79
	10	74.88	10.22	28.77	11.44	702.90
	15	77.40	13.25	33.75	13.90	775.71
	20	80.56	13.65	38.90	15.22	819.29
Mean		70.77	10.02	28.44	11.81	694.21
Magnetization + Soaking	0	55.80	6.77	19.77	8.00	521.43
	5	75.65	7.95	27.88	11.22	686.90
	10	84.30	12.80	34.66	14.53	783.10
	15	86.90	14.00	39.77	14.99	893.38
	20	88.50	14.75	45.80	15.52	982.62
Mean		78.23	11.25	33.58	12.85	773.48
$LSD_{5\%}$ (Treatment)		**1.64**	**0.94**	**1.20**	**1.60**	**ns**
$LSD_{5\%}$ (Time)		**1.24**	**0.93**	**1.08**	**1.60**	**112.14**
Interaction		***	**ns**	***	**ns**	**ns**

The interaction between all treatments and pre-sowing Magnetization treatment different times were significant for plant height (cm) and No. of capsules /plant while the No. of branches /plant, weight of seeds /plant and weight of seeds /ha were no significant. These results are in agreement by indicated that the application of chitosan had increase plant growth (height, leaf number, fresh and dry weight), yield components

(fruit number/plant, fruit weight and total yield) (Ramadan and El-Mesairy, 2015). Chitosan is increase physiological reaction and decreases the negative effects of abiotic stress by secondary messenger(s) via a stress transduction mechanism. Chitosan treatment enhances the closure of stomata and photosynthesis, enhances antioxidant enzymes by nitric oxide and hydrogen peroxide signaling pathways and induces the production of sugars organic acids, amino acids and other metabolites needed for osmotic stress-related adaptation, signaling of stress, and metabolism of energy (Hidangmayum et al., 2019).

The used of chitosan was reduced the impacts of salinity on the previous plants by increasing the activity of antioxidant enzymes, which caused a decrease in the malondialdehyde content (Al-Tawaha et al., 2018). A group researchers indicated that the chitosan foliar application improvement of increasing flowers and pod number, plant length and branches /plant for cowpea (Tartoure et al., 2021). Seeds treated with Magnetization field had a positive effect on the seed germination, seedling growth and reproduction, and growth of meristem cells (Hozain et al., 2014). Also, pre-sowing of seeds with a Magnetization treatment was increased the amount of indole-3-acetic acid and gibberellic acid in germinating seeds, above-ground parts and in roots of faba bean seedlings with increasing of the exposure time. The pre-sowing treatment with a Magnetization field had favorable effects on the growth and development of seedlings (Podlesna et al., 2019). Seeds treated Magnetization field was significant increase of height plant , fresh plant , dry plant and No. fruit under salinity (Samarah et al., 2021).The impact of the Magnetization field was assessed on the basis of the average germination time, which the seeds treatment by Magnetization field had a positive effect on growth seeds. The seeds stimulated with a constant Magnetization field sprouted more than the non-stimulated seeds (Pszczolkowski et al., 2023).

3.3.1 Nutrients concentrations in seeds of plants.

Data presented in Table (4) show that the results of this research confirmed that implementation of pre-sowing Magnetization times for seeds combined with chitosan were increase of N, P and K concentrations in seeds than without Magnetization treatment. The pre-sowing seeds with magnetization times plus soaking in chitosan for seeds led to increase of concentrations of N, K and P in seeds. The Effect of all treatment on N and P concentrations in seeds were significant while the K was no significant. As well as, the Effect of Magnetization different times on N and P concentrations in seeds were significant while the K was no significant and the interaction between treatment and Magnetization times were significant in N and P concentrations while K no significant.

The increase of N, P and K concentrations in grains as treated with chitosan application (Elsaka et al., 2018). The application of chitosan on minerals may be attributed to the increase in microbial population by large numbers, and transform organic nutrient into inorganic nutrients that are easily absorbed by plant root (Ramadan and El-Mesairy, 2015). Application of chitosan to plant led to increased nitrogen, phosphate, and potassium uptake and improved nitrogen transport to leaves (Ullah et al., 2020). Some researhers found that the application of chitosan had increase plant contents of N, P and K in different plant species cultivated under diverse growth conditions showed that the translocation of macro-nutrients from the soil by plant roots to grains was higher in plants treated with magnetized than the non-magnetized (Ramadan and El-Mesairy, 2015; Abd-Elrahman and Osama, 2017). The pre-sowing seeds Magnetization times was improve the characteristics, chemical composition and availability of nutrients in the soil, and nutrients uptake in plants (Abdel Fattah and Esmaeil, 2022).

The Magnetization treatment making on free radicals for elements uptake and improve the biochemical process that enhance plants seed vigor and stimulate proteins and enzyme activities (Stange et al., 2002). Magnetization treatment of seeds pre-sowing by the exposure to a Magnetization field may be preferred compared to the biological and chemical stimulators because it may be free of toxic residues. The Magnetization seed led to improve the nutrients and water uptake for plants, and provide good support to plants due to exposure of seeds to the Magnetization field but do not occur in the untreated seeds (Hussain et al., 2020).

3.4 Micronutrients concentrations in seeds.

Data presented in Table (4) indicated that the increase of Fe, Mn and Zn concentrations in seeds treated with pre-sowing Magnetization increasing period time combined with chitosan compared other treatments. The significant increase of Fe, Mn and Zn concentrations in seeds as affected by all treatments, while the pre-sowing magnetization time was Mn and Zn were significant increase with increasing Magnetization times. Also, the interaction between magnetization times and soaking chitosan were significant of Fe, Mn and Zn concentrations in seeds. On the other hand, the relative increase of mean values Fe, Mn and Zn concentration in seeds as affected with pre-sowing seeds Magnetization treatment times were 11.21% for Fe, 18.29% for Mn and 30.64% for Zn respectively compared without Magnetization, while the soaking seeds in chitosan was 20.74% for Fe , 33.25% for Mn and 41.54% for Zn, respectively, compared without Magnetization.

Table 4: Macro-micronutrients concentrations in Nigella sativa seeds as affected by the studied treaments

Treatment type	Time (min)	Macronutrients (%)			Micronutrients (mg/kg)		
		N	P	K	Fe	Mn	Zn
Magnetization	0	1.83	0.19	1.09	42.10	30.89	23.40
	5	2.21	0.25	1.14	44.28	34.22	25.88
	10	2.23	0.27	1.17	46.10	35.75	31.30
	15	2.32	0.28	1.22	47.88	37.20	31.88
	20	2.35	0.32	1.27	49.00	39.00	33.20
Mean		2.19	0.26	1.18	45.87	35.41	29.13
Soaking	0	1.99	0.20	1.12	44.00	32.66	24.70
	5	2.27	0.27	1.19	46.33	35.90	29.75
	10	3.35	0.35	1.24	50.54	40.43	32.10
	15	3.42	0.39	1.29	52.88	43.30	34.75
	20	3.44	0.42	1.35	53.55	45.00	35.89
Mean		2.89	0.33	1.24	49.46	39.46	31.44
Magnetization + Soaking	0	2.30	0.22	1.16	44.38	34.20	25.60
	5	3.35	0.32	1.20	48.50	37.44	33.54
	10	3.46	0.37	1.27	53.20	38.20	37.40
	15	3.48	0.42	1.32	55.20	42.10	38.00
	20	3.52	0.44	1.36	57.33	45.29	41.20
Mean		3.22	0.35	1.26	51.72	39.45	35.15
$LSD_{5\%}$ (Treatment)		**0.153**	**0.013**	**ns**	**1.66**	**1.47**	**1.32**
$LSD_{5\%}$ (Time)		**0.126**	**0.010**	**ns**	**ns**	**0.94**	**0.45**
Interaction		***	***	**ns**	***	**	***

As well as, the relative increases of mean values were 27.22% for Fe, 31.95% for Mn and 60.43% for Zn, respectively, concentrations in seeds as affected by soaking seeds in chitosan and pre-sowing seeds Magnetization times compared nonMagnetization. Finally, it is concluded that the concentrations of micronutrients in plants, generally, reflect their available contents in soil and long Magnetization time's period. It is worthy to mention that the contents of all the studied concentrations microelements, in general, lay within the sufficient limits of Fe and Mn or in the critical limits identical division for the others (FAO, 1992). These results are in agreement by a group researchers suggested that the spray of chitosan on plant was increase of Fe, Mn and Zn than untreated (Zurawil et al., 2018). The increase content of minerals in the leaves as affected with spray of chitosan-mediated nutrient uptake from the soil.

Some researcher indicated that the increase of time per-sowing seeds Magnetization treatment was increase of micronutrients concentrations in straw and grains (Abdel Fattah and Esmaeil, 2022). Dhaw found that the Magnetization treatment led to increase interaction was increase the macro-micronutrients uptake (Dhaw, 2014). The increase of uptake of elements and stimulate elements do to accumulation differently. These result may be due to increase occurs in chemical reactions of plants under Magnetization treatment, which has a positive effect on photochemical activity, respiration ratio and enzyme activity. A group researcher reported that the pre-sowing Magnetization treatment of seeds the improved plant nutrition caused biochemical variations in the enzymes activities that affect the plant processes like photosynthesis and nutrients uptake (Afzal et al., 2021). The pre-sowing seeds Magnetization treatment different times was increase of Fe, Mn and Zn concentrations in seeds faba bean with increasing times exposure Magnetization for seeds (Shaban et al., 2023).

3.5 Chlorophyll and seeds quality in plants

Data presented in Table (5) and Figure 2 show that the highest values of protein (%), oil and chlorophyll contents in Nigella sativa. plants treated with soaking seeds in chitosan and pre-sowing seeds Magnetization times, while the proline contents in seeds was low than control. On the other hand, the effect of all treatments on seeds quality and chlorophyll were significant. The pre-sowing seeds Magnetization times were significant increase of protein, oil and chlorophyll and decrease of proline content. Also, the interaction between chitosan and Magnetization treatment different times were protein significant, while the proline, oil and chlorophyll were no significant. The increase of protein and oil contents in seeds with increasing Magnetization times and chlorophyll increase with increasing Magnetization times while the proline decrease with increasing Magnetization times.

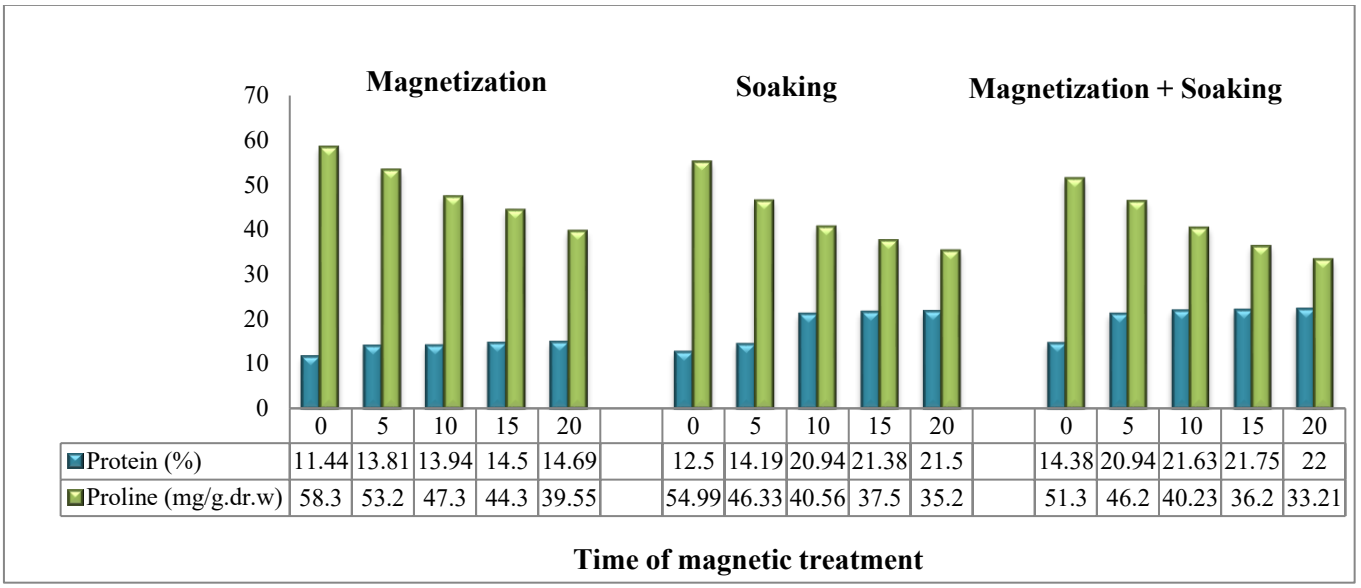


Figure 2: Effect of treatments on the protein (%) and proline (mg/g.dr.w) in Nigella sativa seeds

Table 5: Effect of treatments on the oil content (%) in seeds and chlorophyll in leaves

Treatment type	Time (min)	Oil (%)	Chlorophyll (mg/g.f.w.)
Magnetization	0	32.97	2.25
	5	34.90	2.85
	10	37.32	3.14
	15	38.54	3.22
	20	39.85	3.46
Mean		36.72	2.98
Soaking	0	35.85	2.89
	5	37.50	3.15
	10	38.65	3.28
	15	39.60	3.59
	20	41.20	3.66
Mean		38.56	3.31
Magnetization + Soaking	0	37.40	3.07
	5	39.60	3.48
	10	40.32	3.69
	15	40.88	3.88
	20	41.88	4.03
Mean		40.02	3.63

Table 5 (cont): Effect of treatments on the oil content (%) in seeds and chlorophyll in leaves		
$LSD_{5\%}$ (Treatment)	**0.72**	**0.33**
$LSD_{5\%}$ (Time)	**1.57**	**0.44**
Interaction	**ns**	**ns**

These results are in agreement by a group researchers found that priming of mung bean seeds with chitosan was an increase in protein content compared to the control (Lyalina et al., 2023). A group researchers reported that the seeds soaking in chitosan led to increase of protein content (Liu et al., 2022). Emphasize that 0.15–0.20% chitosan soaking could increase of protein, effectively enhance protein in leaves, thereby effectively promoting their stress resistance, environmental adaptability, and healthy growth. Some researchers suggested that the Soaking seeds lupine plants caused significant decreased in proline and increase of protein contents (Bakhoum et al., 2022). In a study showed that the increase of protein content in soybean as treated with Magnetization field for seeds but decrease of proline contents in soybean seed (Rashad et al., 2022). Researcher indicated that the treated of seeds with Magnetization field influences the proteins and fatty acids (Radhakrishnan, 2018). The results suggest that the seeds treated of Magnetization field led to increase of protein content.

Some researchers suggested found that the best exposure period Magnetization field for acceleration of callus initiation was (30 min) (Al-Allaf and Al-Baker, 2022). Also, protein, proline and carbohydrates content and callus vitality got a better result under (90 min) of Magnetization field exposure. Chitosan combined with Magnetization treatment different times treatments in Nigella sativa plants showed improvements in morphological traits, photosynthetic pigments. Besides, the harmful impacts of salinity on Nigella sativa plants. Salinity stress reduced total chlorophylls in Nigella (*Nigella sativa* L.). Photosynthetic content varied considerably with respect to the Magnetization field time's exposure duration. The Magnetization treatments enhanced total chlorophylls content in control and stress conditions. Also, the effect of Magnetization field on chlorophylls appeared to depend on the Magnetization time and the exposure period.

The pre-sowing seeds treated of Magnetization treatment 20 min exposure had an enhancement effect on chlorophylls. A study indicated that seeds exposure time of Magnetization field led to increase for chlorophyll content in plant (Ibrahim, 2015). The Magnetization field used may be to the increase the inner energy, increment of the inner energy that involved in metabolism, chemical reactions enhance growth further development and the ability to increase the assimilatory chlorophyll level (Strzalk et al., 2003). The Magnetization field treated with seeds caused increasing reactive oxygen species, may lead to increase in carotenoids level due to its role in protecting plant system. As any organic chemical structure chloroplasts have paraMagnetization properties which can be affected by MF and may be oriented toward Magnetization field direction (Sahebjamei et al., 2007).

4. Conclusion

This study has indicated that pre-sowing magnetic treatment with and without soaking in chitosan solution of the Nigella (*Nigella sativa* L.) seeds for different time intervals has enhanced its productivity and quality under saline calcareous soil conditions. The treaments decreased the effect of soil salinity and increased the values of the plant quality parameters. Magnetization of seeds can be an effective technique to improve the yield of crops and to alleviate the negative impact of soil salinity on crop productivity.

Declarations

Ethics approval and consent to participate

Consent for publication: The article contains no such material that may be unlawful, defamatory, or which would, if published, in any way whatsoever, violate the terms and conditions as laid down in the agreement.

Availability of data and material: Not applicable.

Competing interests: The authors declare that they have no conflict of interest in the publication.

Funding: Not applicable.

Authors' contributions: Authors K.A.H.S., M.I.M., E.A.S. and N.M.E. have designed the study, followed the field experiments, carried out the lab tests and analysis, arranged the output data, wrote the original draft and finalize the manuscript. All authors read and agree for submission of manuscript to the journal.

Acknowledgments

The authors would like to thank very much the Company of Delta Water for Magnetization Water Treatment Technology as they provided the permanent magnet instrument for research and scientific purposes.

References

A.O.A.C. 1980. Official Methods of Analysis of the Association of Official Agricultural Chemists (A.O.A.C.) 12th Ed. Washington. D.C.

Abdel- Fattah, A.K. and Esmaeil, M.A., 2022. Effect of pre-sowing Magnetization treatment of maize seeds on its productivity and on some soil properties. Asian J. of Plant and Soil Sci., 7 (1), Pp. 262 – 272.

Abd-Elrahman, Sh.H. and Shalaby, O.A., 2017. Response of wheat plants to irrigation with magnetized water under Egyptian soil conditions. Egypt. J. Soil. Sci., 57 (4), Pp. 477 – 488.

Abdul, M.H., Ataur, M.R., Abdullah, A.S., Jamal, M.U., Raju, D., Mahmudul, H.S., Saidur, R., 2021. Black cumin (Nigella sativa L.) :Acomprehensive review on phytochemistry, health benefits, molecular pharmacology, and safety. Nutrients J., 13 (6), Pp. 1784-1794.

Abedinpour, M., and Rohani, E., 2017. Effect of mangnetized water on soil and maize growth indices under saline water.J.of water reuse and Desalination, 7, Pp. 320 – 325.

Abou El-Yazied, A., El-Gizawy, A.M., Khalf, S.M., El-Satar, A., and Shalaby, O.A., 2012. Effect of Magnetization field treatments for seeds and irrigation water as well as N, P and K levels on productivity of tomato plants," Journal of Applied Sciences Research, 8 (4), Pp. 2088-2099.

Afzal, I., Saleem, S., Skalicky, M., Javed, T., Bakhtavar, M.A., Haq, Z., Kamran, M., Shahid, M., Saddiq, M.S., Afzal, A., Shafqat, N., Dessoky, E.S., Gupta, A., Korczyk-Szabo, J., Brestic, M., and Sabagh, A.E.L., 2021. Magnetization field treatments improves sunflower yield by inducing physiological and biochemical modulations in seeds. Molecules, 26, Pp. 1-14.

Ahmed, M.A., Mohaseb, M.I., El-Sheikh, N.M., and Shaban, K.A., 2024. Evaluation of methods of adding chitosan and potassium silicate on some soil fertility and cowpea (vignaungicultata).Plant productivity. Asian J. Soil Sci. Plant Nutri., 10 (1), Pp. 1-13.

Al-Allaf, S.J.A., and Al-Baker, R.A.H., 2022. Effectiveness of Magnetization field in stimulation ofbiochemical and enzymes activities in seedling and callus of Nigella sativa. International Journal of Health Sciences, 6 (S2), Pp. 3301–3314.

Al-Huqail, A.A., Alqarawi, A.A., Hashem, A., Malik, J.A., and Abd_Allah, E.F., 2019. Silicon supplementation modulates antioxidant system and osmolyte accumulation to balance salt stress in Acacia gerrardiiBenth. Saudi journal of biological sciences, 26 (7), Pp. 1856-1864.

Al-Tawaha A.R., Turk M.A., Al-Tawaha A.R.M., Alu'datt M.H., Wedyan M., Al-Ramamneh E. and Hoang A.T., 2018. Using chitosan to improve growth of maize cultivars under salinity conditions. Bulg. J. Agric. Sci., 24, Pp. 437–442.

Ashwini, H.G., and Manjunatha, H., 2018. Effect of Magnetization treatment on leaching efficiency of salts.international Journal of CurrientMicrobio land Applied Sciences. 7 (3), Pp. 3363- 3367.

Bakhoum, G.S., Sadak, M.S., and Tawfik, M.M., 2022. Chitosan and chitosan nanoparticle effect on growth, productivity and some biochemical aspects of lupinustermis l plant under drought conditions. Egyptian J. of Chemistry . Egypt. J. Chem., 65 (5), Pp. 537 – 549.

Bates, L.S., Waldren, R.P., and Teare, I.D., 1973. Rapid determination of free proline under waterstress studies. Plant and Soil, 39, Pp. 205-207.

Bukhari, S.A., Tanveer, M., Mustafa, G., and Zia-Ud-Den, N., 2021. Magnetization Field Stimulation Effect onGermination and Antioxidant Activities of Presown Hybrid Seeds of Sunflower and Its Seedlings.ResearchArticle.Journal of Food Quality, 1, Pp. 1-9.

Chandrkachang, S., 2002. The application of chitin and chitosan in agriculture in Thailand . Advances in Chitin Sci., 5, Pp. 458- 462.

Chapman, H.D., and Pratt, R.E., 1961. Methods of Analysis for Soil, Plants and Water. Department of Soil and Plant Nutrition,University of California, U.S.A.

Cheung., R.C.F., Ng, T.B., Wong, J.H., and Chan, W.Y., 2015. Chitosan: An Update on Potential Biomedical and Pharmaceutical Applications. Mar. Drugs, 13 (8), Pp. 5156-5186.

Daneshm, A., and Alamdari, G.M., 2014. Effects of different nitrogen amounts and potassium silicate foliar application on agronomic traits and seed yield of rice tarom cultivar. J. Crop Prod. Res. (Environ. Stresses In Plant Sci.), 6 (2), Pp. 107-118.

Dhawi, F., 2014. Why Magnetization fields are used Enhance a plants growth and productivity ?. Annual Research. Review in Biology, 4 (6), Pp. 886 – 896.

Dubois, M., Gilles, A., Hamelton, J.K., Robers, P.A., and Smith, P.A., 1956. A colorimetric method fordetermination of sugar and related substances.Annal.Chem., 28, Pp. 350- 356.

El-Leithy, A.S.I., Abdallah, S.A.S., and Ali, M.A.M., 2019. Effect of soil application with nitrogen levels and potassium silicat foliar spray on growth and yield of Balck Cumin (Nigella sativa L.).SINAI Journal of Applied Sciences, 8 (2), Pp. 185 – 198.

Elsaka, M.S., Aboelsoud, H.M., and Khalifa, T.H., 2018. Chitosan and soluble Calcium effect on plant systems under salinity stress. J. Soil Sci. and Agric. Mansoura . Univ., 9 (12), Pp. 865 – 871.

El-Sonbaty, A.E., 2021. Effect of organic matter combined with mineral N fertilizers different rates with or without Magnetization water on soil fertility and maize productivity. Journal of Plant Cell Biotechnology and Molecular Biology, 22 (67 &68), Pp. 96–112.

FAO, 1992. Waste water treatment and use in agriculture. FAO Soils Bull. No.47, Rome.

Farzad, R., 2023. Chitosan as an organic amendment to improve soil properties and plant growth in the presence of polystyrene microplastics.EnvironProg Sustainable Energy, 3, Pp. 1- 18. Doi. 10.1002/ep.14301.

Giridhar, K., Reddy, G.S., Kumari, S.S., Kumari, A.L., and Sivasankar, A., 2017. Influence sowing window and plant density on growth , phenology, yield and quality of Nigella sativa L. in coatal humid tropic. Intr. J. Curr. Microbiol. App. Sci., 6 (9), Pp. 499 – 512.

Gomaa, M., Fathallah Rehab, I., Kandil, E.E., and Ali, A.M.M., 2021. Using of potassium silicate to alleviate drought stress effect on peanut as grown in sandy soil. Journal of the Advances in Agricultural Researches, 26 (3), Pp. 109-119.

Hassanzadehdelouei, M., Vazin, F., and Nadaf, J., 2013. Effect of salt stress in different stage of growth on qualitative and quantitative charactersitics of cumin (Cuminumcyminun L.).CercetăriAgronomiceîn Moldova, 1 (153), Pp. 89 – 92.

Hidangmayum, A., Dwivedi, B., Katiyar, D., Hemantaranjan, A., 2019. Application of chitosanon plant responses with special reference to abiotic stress. Physiol. Mol. Biol. Plants, 25 (2), Pp. 313–326.

Hozayn, M., El-Monem, A.A., Elwia, T., El-Shatar, M., 2014. Future of Magnetization agriculture in arid and semi arid regions (case study). Sci. Pap. Ser. Agron., 57, Pp. 197–204.

Hussain, M., Dastgeer, G., Afzal, A., Hussain, S., and Kanwar, R., 2020. Eco-friendly Magnetization field treatment to enhance wheat yield and seed germination growth. Environmental Nanotechnology, Monitoring and Management, 14, Pp. 100299.

Ibrahim, A.H., 2015. Influence of different intensities of Magnetization field on germination, vegetative growth and some physiological aspects of salinity-stressed cucumber.The Egyptian Society for Environmental Sciences, 10 (1), Pp. 59 – 67.

Ibrahim, H.M., and Arafa, S.A., 2020. Effect of chitosan on growth , yield and certain salinity stress- related metabolites in two barley cultivars contrasting in salt tolerance. J. of Plant Production, Mansoura Univ., 11 (10), Pp. 899-906.

Jakubowska A., 2004. The mechanism of IAA level regulation in plants. (in Polish). MikołajKopernik University, Toruń, Pp. 1–116.

Klute, A., 1986. Methods of Soil Analysis. Part I, Soil Physical properties. ASA and SSSA, Madison, WI.

Liu, H., Zheng, Z., Han, X., Zhang, C., Li, H., and Wu, M., 2022. Chitosan soaking improves seed germination of platycodon grandiflorus and enhances its growth, photosynthesis, resistance, yield, and quality. Horticulturae J., 8 (943), Pp. 1- 13.

Lyalina, T., Shagdarova, B., Zhuikova, Y., Alexey, A., and Varlamov, V., 2023. Effect of seed priming with chitosan hydrolysate on lettuce (lactuca sativa) growth parameters. Molecules J., 28, Pp. 1- 17.

Malekpoor, F., Ghasemi, A.P., and Salim, A., 2016. Effect of foliar application of chitosan on morphological and physiological characteristics of basil under reduced irrigation. Res. on Crops., 17 (2), Pp. 354 – 359.

Marghayizadeh, G.H., Gharineh, M.H., Fathi, Gh., A., Abdali, A.R., and Farid, M., 2014. Effect of ultrasonic waves and Magnetization field on germination, growth and yield indices (Carumcopticum (L), C. B. Clark) in laboratory and field conditions. Scientific and Research Bimonthly Journal of Medicinal and Aromatic Herbs, 30 (4), Pp. 539-560.

Mead, R., Currow, R.N., and Harted, A.M., 1993. Statistical methods in agricultural and experimented biology. 2nd Ed. Chapman and Hall, Landon, Pp. 10-44.

Mohamed, S.A., Ahmed, H.S., El-Baowab, A.A., 2018. Effect of chitosan ,putrescine and irrigation levels on the drought tolerance of sour orange seedling. Egypt J. Hort. 45 (2), Pp. 257 – 273.

Page, A.L., Miller, R.H., Keeney, D.R., 1982. Methods of soil analysis. Part 2.Chemical and microbiological properties, Agronomy, No. 9. Soil Sci. Soc. Amer., Madison, WI, Pp. 1159.

Podleśna, A., Bojarszczuk, J., and Podlesny, J., 2019. Effect of Pre-sowing Magnetization Field Treatment on Some Biochemical and Physiological Processes in Faba Bean (Viciafaba L. spp. Minor).Journal of Plant Growth Regulation, 38, Pp. 1153 – 1160.

Pourakbar, L., Ashrafi, R., and Asadi, M., 2012. The effect of Magnetization field on the germination of black cumin seeds.Proceedings of the Congress of Science and Agronomy and Plant Breeding.Faculty of Science, University of Science, Pp. 29- 38.

Pszczolkowski, P., Sawicka, B., Skiba, D., Barbara, P., Krochmal-Marczak, B., 2023. Effect of pre-sowing Magnetization field stimulation on the seed germination and growth of Phaseolus vulgaris L. Plants. Agronomy J., 13 (793), Pp. 1- 20.

Radhakrishnan, R., 2018. Seed pretreatment with Magnetization field alters the storage proteins and lipid profiles in harvested soybean seeds. Physiol Mol Biol Plants, 24 (2), Pp. 343 – 347.

Radhakrishnan, R., 2019. Exposure of Magnetization waves stimulates rapid germination of soybean seeds by enzymatic regulation in cotyledons and embryonic axis. Biocatalysis and Agricultural Biotechnology, 20, Pp. 101273.

Ramadan, M.E., El-Mesairy, M.M.A., 2015. Effect of humic acid and chitosan on growth and yield of okra (Abelmoschus Esculents L.) under saline conditions. Egyptian J. Desert Res., 65 (1), Pp. 47 – 60.

Rashad, R.T., Shaban, K.A.H., Ashmaye, S.H., Abd El-Kader, M.G., and Mahmoud, A.A., 2022. Effect of pre-sowing Magnetization treatment of seeds with bio- and mineral fertilization on the soybean cultivated in a saline calcareous soil. Saina Tanah, J. of Soil Sci. Agroclimatology, 19 (2), Pp. 132 – 144.

Rashed, N.M., Shala, A.Y., and Mahmoud, A.M., 2017. Alleviation of salt stress in Nigella Sativa L.ByGibberellic Acid and Rhizobacteria.Alexandria Science Exchange Journal, 38 (4), Pp. 785 – 799.

Ratushnyak, A.A., Andreeva, M.G., Morozova, O.V., Morozov, G.A., and Trushin, M.V., 2008. Effect of extremely high frequency electroMagnetization fields on the microbiological community in rhizosphere of plants. Int. Agrophysics, 22, Pp. 71-74.

Sahebjamei, H., Abdolmaleki, P., and Ghanati, F., 2007. Effects of Magnetization field on the anti oxidant enzyme activities of suspension-cultured tobacco cells. Bio electroMagnetizations. 28, Pp. 42-47.

Samarah, N.H., Ibrahim, M.M., and Makhadmeh, I.M., 2021. Effect of Magnetization treatment of water or seeds on germination and productivity of tomato plants under salinity stress. J. Harticuliture, 7 (220), Pp. 1- 11.

Shaban, K.A.H., Mohaseb, M.I., Kamel, G.H., and El-Sayed, H.A.M., 2023. Effect of bio and organic fertilizations and per-sowing seeds Magnetization field combined with mineral nitrogen fertilizer on some soil properties and faba bean productivity and quality under saline soil conditions. Intr. J. of plant and Soil Science, 35 (7), Pp. 17 -33.

Shehata, M.N., and Abdelgawad, K.F., 2019. Potassium and amino acids improve growth, flowering and productivity of summer squash under high temperature condition. American-Eurasian J. Agric. and Environ. Sci., 19 (2), Pp. 74-86.

Stange , B.C., Rowland, R.E., Rapley, B.I., and Podd, J.V., 2002. Magnetization field increase amino acid uptake into ViciafabaL. roots and alter ion movement across the plasma membrane.Bioelectromag, 33, Pp. 347-354.

Strzalka, K., Kostecka-Guga, A., and Latowski D., 2003. Carotenoids and environmental stress inplants: significance of carotenoid-mediated modulation of membrane physicalproperties. Russ J Plant Physiol., 50, Pp. 168-173.

Tartoure, E.A., Ahmed, H.M., and El-Sayed, S.S.M., 2021. Optimization of cowpea productivity and seed quality under soil natural salinity stress using some different protective treatments. Plant Production, Mansoura Univ., 12 (7), Pp. 711-718.

Ullah, N., Basit, A., Ahmad, I., Ullah, I., Shah, S.T., Mohamed, H.I., Javed, S., 2020. Mitigation the adverse effect of salinity stress on the

performance of the tomato crop by exogenous application of chitosan. Bull. Natl. Res. Cent., 44, (181), Pp. 10 11.

Witham, F.H., Blaydes, D.F., and Devin, P.M., 1971. Experiments in plant physiology.Van Nosland Reihold.Co. New York, Pp. 55-58.

Zhou B., Yang L., Chen X., Peng Y., and Liang C., 2021. Effect of Magnetization water irrigation on the improvement of salinized soil and cotton growth in Xinxiang. Journal of Agricultural Management, 248 (1), Pp. 1-6.

Żurawik, P., Żurawik, A., and Kukla, P., 2018. Content of macro- and micronutrients in chitosan treated freesia (Freesia Eckl. ex Klatt) leaves. Acta Sci. Pol. Hortorum Cultus, 17 (6), Pp. 7–16.