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Impact of Magnetic Technology on Germination, Seedling vigour, Growth, Yield, and Nutritional value of Groundnut (*Arachis Hypogaea* L) under Water Salinity Stress Conditions in Sandy Soil

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Abstract

Legume field crops, involving groundnuts, in the Nubaria region, are exposed to salinity stress in irrigation water, where, most of time, relied for their irrigation on well water, which contains various levels of salinity (2500-3000 ppm), particularly in the event of a deficiency or delay for water in the Nubaria Canal. Laboratory and field experiments using groundnut (*Arachis hypogaea* L; Var Giza-6) were performed to mitigate water salinity stress on photosynthetic pigments, growth, germination, yield and yield components of groundnut. Laboratory experiment was conducted at Laboratory of Seed Technology Deaprtment, Field Crops Research Institute, Agricultue Research Center, Giza, Egypt, and two field trials were carried out at Experimental Research and Production Station of National Research Centre, El-Emam Malak Village, El-Noberia District, El-Beheira Governorate, Egypt during summer seasons of 2021 and 2022. Results of laboratory experiment displayed marked increases regarding implementation of various magneto-priming seed treatments (T_1-T_5; 0.05, 0.11, 0.19, 0.27, 0.32 Tesla) compared to untreated (implanting dry seeds). As an average of all magneto-priming treatments (T_1-T_5), the improvement percentages compared to untreated seed reached by 12.13% in seed germination (G), 12.13% in germination index (GI), 15.83% in speed germination index (SGI), 12.13% in germination energy (GE), 2.88% in germination rate (GR; day), 26.95% in seedling length (SL; cm), 38.35% in seedling weight (SW; G). In addition seedling vigor-I and seedling vigor-II of groundnuts they were increased by 42.75 and 55.71%, respectively. Similar positive impacts were noticed in Mean Germination Time (MGT; day) where the treated seeds were speedier germinated by 8.99% compared to untreated ones. The best magnetized-seeds treatment (T_4) was applied under field conditions as general traetments, where irrigation with water passed through magnetic device (Two inch, produced by NRC; 0.24 - 0.28 Tesla) induced positive significant effect on groundnut growth, total chlorophyll at 90 DAS, yield components, yield (ton fed^{-1}) and nutritional value of seeds at harvest under sprinkler or drip irrigation systems. The percentage of improvement ranged between 9.78 – 15.97%, 14.04-15.97%, 5.15-22.17%, 16.25-20.26%, and 3.48-12.12% in the above-mentioned parameters, respectively. Under conditions of experiments, it could be concluded that the application of magnetized water and seed technologies alleviated salinity water stress which resulted in the improvement of growth and productivity of groundnuts under Nubaria region**.**

Keywords: Groundnut, Magneto-Priming Seeds, Magnetized Water technology, Salinity stress, Germination, Seedling vigour, Growth, Nutritional Value, Yield, Sandy soil

1. Introduction

Groundnut, (*Arachis hypogaea* L.) is a multi-purpose legume crop broadly implanted in subtropical and tropical regions. It is one of the most summer oil crops in the world, because of its seeds are rich in oil (35–56%). In addition, the seeds are commonly used for human consumption and animal feed for their high nutritive value and calorie richness (5.6 cal/g).

Its seeds also contains protein by 25– 30%, carbohydrates (9.5–19.0%), fibers (5-7 %), as well as minerals (Ca, K, Mg and P) and vitamins (B, E and K) [1]. In Egypt, Groundnut has been given great interest due to its convenience for growing in the newly reclaimed sandy areas [2]. During 2019, the cultivated area of Groundnut in Egypt was approximately sixty-six hectares, with a total production of 231.22 tons [3].

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The crop plays a fundamental role in ameliorating soil fertility and maintaining soil moisture thereby sharing to the reduction of households' vulnerability to weather-associated shocks while modulating post-shock resilience [4]. Moreover, groundnut is an exemplary crop in rotational systems to improve soil fertility better because of its natural capacity to fix atmospheric nitrogen [5]. Groundnut has different industrial uses comprising products such as feed, food, lubricants, paints, rather than insecticides [6]. So, it is considered a cash crop due to its economic significance and ability to bring income for numerous countries. The crop has a good ability to thieve in light soil, and shares in improving the merits of the newly reclaimed sandy soils, which frequently suffer from some limitations in soil and irrigation water such as poor physical characteristics and nutrients shortage [7]. Commonly, Groundnut is most sensitive to water stress in growth phases like other plants. Adequate irrigation and soil moisture in plant production are essential requirements for genesis of groundnut pods [8].

Because of the increasing water deficiency, it is essential to optimize the use of water, primarily for irrigation intents [9]. Rainfall is rare in arid and semi-arid regions where, scarce water resources which limited to ground water that denoted all life manners. Surface irrigation is the prime popular system in these regions [10]. Therefore, maintaining of strategic water reserves is the critical factor for all agriculture mechanisms. Implementation of modern irrigation methods in this operation is substantial for minimizing irrigation water requirements [11].

Productive irrigation systems require the selection of convenient method for the crop growth, adequate monitoring of water delivery and sufficient application rates relying on the growth phase of the crop to maximize the getting back of water unit used for irrigation. So, concerning environmental impacts; water scarcity and of fertilizer overuse, the most functional irrigation system as well as the optimum fertilizer regime should be considered [12].

Consequently, the economic use of water is a key issue that confronts farmers and agricultural scientists in the harsh environmental conditions. Awareness about the appropriate amounts of irrigation water is substantial to get an economically maximum output of numerous crops. Unsuitable irrigation method causes considerable water losses in most irrigation regimes.

Moreover, it is known that, the ideal scheme of irrigation in peanut production is implemented overhead with a pivot or lateral sprinkler system; while another technique receiving some grower approval; subsurface drip irrigation (SDI) [13].

Implementation of magnetic technology (MT) for seeds and/or irrigation water in agriculture is a novel method used for improving the productivity of various crops under normal or stressed circumstances [14-17]. Magnetic technology as promising technology used to minimize salinity stress in irrigation water, the soil alkalinity, and induce high leaching of over soluble salts [18-19]. Magnetic technology for seed and/or irrigation water boosted crop growth, germination and yield without any noxious or harmful impact [17, 20-22], moreover, it is considered an eco-friendly new technology [23]. In this issue, Magnetized water technology (MWT) enhances the useful alterations in physical and chemical merits of water, soil and plant. The activity of MW (i.e., the capability of water to interact with other ingredients, such as solubility, reaction rate, etc.) is obviously promoted [24], which is very important in ameliorating water availability and resisting stress conditions [25]. The objective of this study is to estimate the effect of magnetized water treatment under drip and sprinkler irrigation systems on germination, seedling growth, growth plant, yield and osmo-protectants of groundnut irrigated with salinity water.

2. Materials and methods

Laboratory and field experiments using groundnut (*Arachis hypogaea* L.; Variety Giza-6) were carried out at Laboratory of Seed Technology Department, Field Crops Research Institute, Agriculture Research Center (ARC), Giza, Egypt, and and two field trials were carried out at Experimental Research and Production Station of National Research Centre (NRC), El-EmamMalak Village, El-Noberia District, El-Beheira Governorate, Egypt, respectively during summer seasons of 2021 and 2022. The trials evaluated the effect of mitigation of salinity stress using magnetized seeds and water technology on germination, growth, photosynthetic pigments, yield and yield components of groundnut. The laboratory and field experiments were performed as persuading procedure:

2.1 Laboratory experiments

Laboratory trial using ground nut (var. Giza-6) were performed to assess the impacts of magneto-priming treatments (Table 1) on germination traits of groundnut. The treatments were planned in completely randomized design (CRD) with four replications. The seeds were gained from Field Crops Research Institute, Agriculture Research Centre, Giza, Egypt.

Table 1. Description of magneto-priming treatments seed treatments under laboratory circumstances.

C_1	**Control-1:** Germinated dried seeds with fresh water
T_1	Seeds were soaked in magnetized water (MW) for 2 hours (**MW:** it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.04 - 0.06 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.
T_2	Seeds were soaked in magnetized water (MW) for 2 hours (**MW:** it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.1 - 0.12 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.
T_3	Seeds were soaked in magnetized water (MW) for 2 hours (**MW:** it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.18 - 0.20 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.
T_4	Seeds were soaked in magnetized water (MW) for 2 hours (**MW:** it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.26 - 0.28 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.
T_5	Seeds were soaked in magnetized water (MW) for 2 hours (**MW:** it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.30 - 0.32 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.

Germination procedure: Germination test was conducted according to [26]. Whereas, twenty five seeds of examined crops were planted in each replication in sterilized Petri dishes and overlaid at the bottom with 2 sheets of Whitman filter paper, then set in an incubator at 20±2°C. The total numbers of germinated seeds were counted daily and on the 12th day, Germination percentage was calculated. Measurements were done on seedling root, shoot and length (cm) as well as fresh and dry weight (g). In addition, other germination and seedling parameters were calculated as follows:

Seed germination (G; %) = (No. of normal seedling/No. of seeds) × 100; germination percentage was carried out following guidelines of International Seed Testing Association [ISTA ; 27] and defined as the total number of normal seedlings after twelve days.

Germination Energy (GE) = $((N_1+N_2)/M) \times 100$; where N_1 and N_2 represent first and second counts; M = total number of sowed seeds, GE is defined according to [28].

Germination Index (GI) = $(N_1+N_2+N_3+N_4+\ldots)/Ti$; where N_1, N_2, N_3, and N_4 constitute first, second, third, and four counts, etc.., respectively while Ti represents count time, calculated as described in the Association of Official Seed Analysis [AOSA; 29]. Seeds were looked germinated when the radical was at least 2 mm length.

Germination Rate (GR): It was calculated according to the following formula [30]; GR= a + (a +b) + (a + b + c) …….. (a + b + c + m) / n (a + b + c + m), where 'a, b, c' represent No. of seedlings in the first, second and third count, while 'm' is No. of seedlings in final count, and n is the number of counts.

Mean Germination Time (MGT; day): It was calculated relied on the equation of Ellis and Roberts [31]. MGT= $(N_1 \times T_1) + (N_2 \times T_2) + (N_3 \times T_3) + (N_1 \times T_4) + (Ni + Ti)/ N_1 + N_2 + N_3 + N_4 + \ldots N_i$; where N_1, N_2, N_3 and N_4 represent first, second, third and four counts, respectively while T_1, T_2, T_3 and T_4 constitute time of first, second, third and four counts, respectively.

Seedling root and shoot length (cm): It was measured of ten normal seedlings at twelve days after sowing.

Seedling fresh and dry weight (g): Ten normal seedlings were measured at twelve days after planting to estimate fresh weight then the seedlings were dried in a hot-air oven at 85^o C for twelve hours to gain the seedlings dry weight (g).

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

Seedling Vigor-II (SV-II): It was calculated using the following equation: **SV-II**=Germination percentage x seedling dry weight (g)

Statistical analysis: Data were statistically analyzed using an analysis of variance (ANOVA) of a Completely Randomized Design using M-Stat program [32]. Least Significant Difference ($LSD_{5\%}$) was implemented to compare mean values.

2.2 Field Experiments:

Two field experiments using groundnut (var. Giza-6), were performed at Research and Production Station belonging to NRC, El-EmamMalak Village, El-Nubaria District, El-Beheira Governorate, Egypt during summer months of 2021 and 2022. Irrigation with magnetized and un-magnetized saline water was compared under sprinkler and drip irrigation systems on groundnut growth, total chlorophyll, yield (ton fed-1; fed=4200m^2), and yield components. The locations of experimental soil as well as irrigation water were analysed according to Chapman and Pratt method [33] (Table 2).

Table 2. Analysis of soil and irrigation water in the location of field experiments

	Soil depth (0-30 cm)		Irrigation water	
Parameter	**Un-Magnetized saline water (Un-MW)**	**Magnetized Saline water (MW)**	**Un-Magnetized saline water (U-MW)**	**Magnetized Saline water (MW)**
	Particle size distribution			
Coarse sand	48.20	54.75	--	..
Fine sand	49.11	41.43	--	..
Clay + Silt	2.69	3.82	--	..
Texture	Sandy	Sandy	--	..
pH (1:2.5)	8.93	8.60	8.28	8.43
EC(ds cm^{-1};1:5)	3.80	3.10	3.52	3.47
$CaCO_3$ (%)	2.75	2.75	--	…
Organic matter (%)	0.02	0.05	--	…
	Soluble cations (mq/100g soil)			
Na^+	23.58	16.49	27.22	25.11
K^+	2.52	2.16	0.48	0.59
Ca^{++}	2.63	3.15	3.25	3.35
Mg^{++}	9.28	9.20	4.25	4.46
	Soluble anions (mq/100g soil)			
CO^-_3	0.00	0.00	--	…
HCO^-_3	1.17	2.12	5.00	5.50
Cl^-	17.13	14.63	10.00	10.00
SO^{--}_4	19.71	14.26	20.20	20.20

Cultivation method and layout of experiment: The soil was tiwcely ploughed, ridged at 0.60 meters apart, and sectioned into plots with area (30 m long x 18 m width).

During soil preparation for planting, two hundred kg fed^{-1} calcium superphosphate (15.5% P_2O_5) was applied. Seeds were soaked in magnetized water (MW) for 2 hours (MW: it was obtained by pathing the normal water through magnetic unit 0.5 inch; 0.26 - 0.28 produced by NRC), then the magnetized seeds were dried using tissue, then seeds were sown.

Recommended seeds rate (45-50 kg fed^{-1}) of groundnut were coated just before sowing with the bacteria inoculants, using Arabic gum 40% as an adhesive agent, and were implanted in hills 10-15 cm apart at the first week of May in both summer seasons. Sprinkler and drip irrigation systems were applied immediately after planting and as requirements of the plants during the experiment's time.Addition of ammonium sulfate (20.60 N%) at the rate (45 kg N fed^{-1}) was done as nitrogen fertilizer in three equal doses starting at soil preparation, fifteen and thirty days from sowing. Potassium sulfate (48 % K_2O) was added as potassium fertilizer ~~at~~ the rate of (24 kg K fed^{-1}) was added during seedbed soil preparation.

During flowering and the starting pods synthesis, a one hundred kg fed^{-1} calcium nitrate was supplied. Other recommended agricultural practices for sowing groundnut were applied following Agriculture Research Centre leaflet under the experimental region circumstances.

The Groundnut was manually harvested at the second week of September during both seasons. The design of the experiment is displayed in (Fig 1).

Treatments: The field trials were included two treatments: Control treatment was irrigated with well water, while the other treatment was irrigated with saline well water after magnetization through passing into a two-inch Magnetic Unit 'produced by NRC, 0.24-0.28 Tesla. The both treatments were applied under sprinkler and drip irrigation systems.

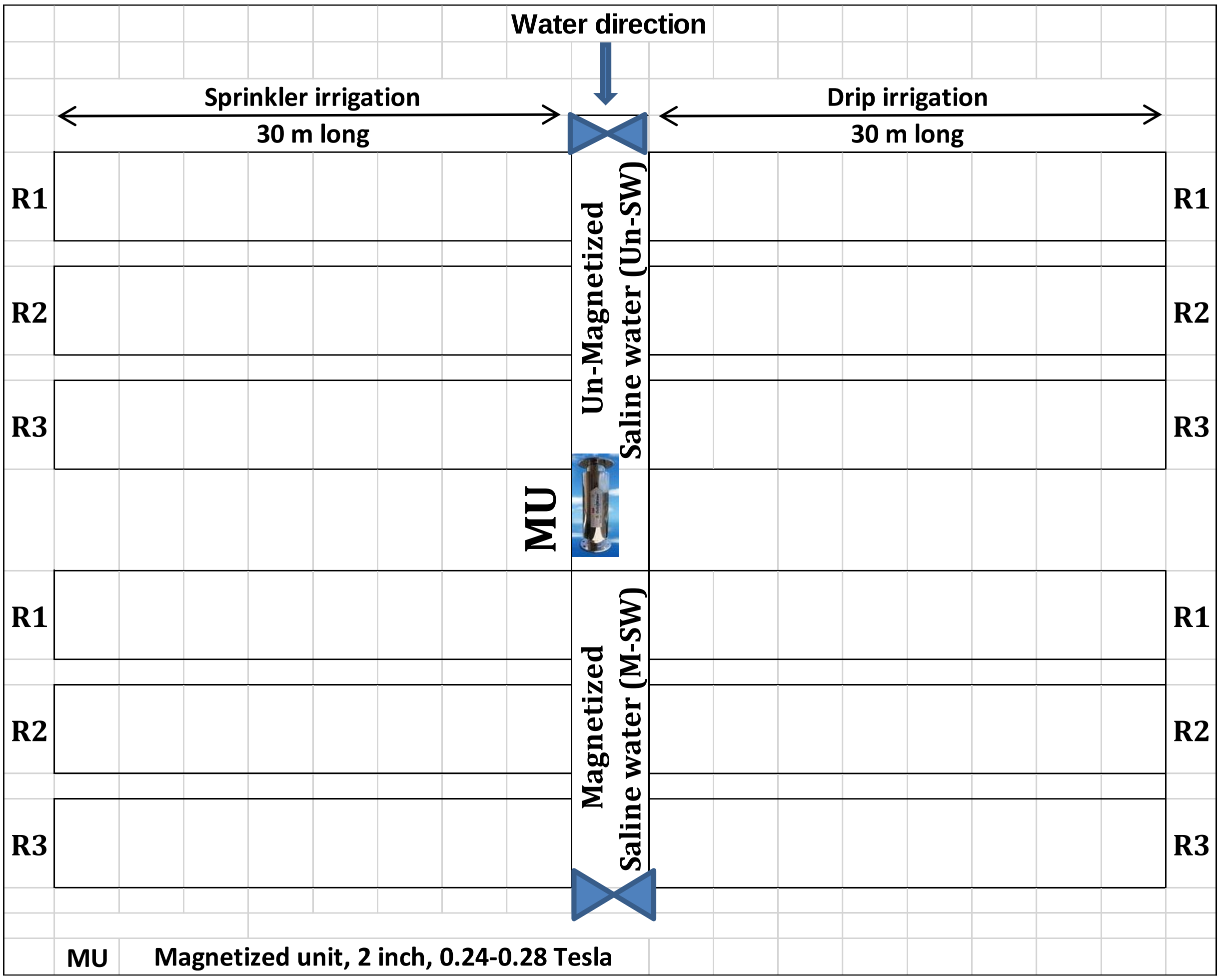

Fig 1. Layout of experimental design under solid set sprinkler and drip irrigation systems

2.3 Data recorded:

Growth parameters (90 DAS): At seventy-five and ninety days after sowing (DAS), ten plants were randomly taken from each plot to record dry weight (g plant^{-1}) and plant height (cm).

Total Chlorophyll: At 90 DAS, total Chlorophyll was determined using SPAD Chlorophyll meter as mentioned by [34].

Groundnut yield and yield components: At harvest, a random sample of ten guarded plants was chosen from each experimental unit to deduct groundnut yield components (i.e., plant height (cm), branches, leaves and pods (no. plant^{-1}), pods and seeds weight (g plant^{-1}) and 100- seeds weight (g). Plants in the two inner ridges were harvested by hand to estimate the total aboveground biological yield. For the same harvested area, pods were isolated and then air-dried to determine the seed yield/plot, which was then transformed to feddan (Fed=4200 m^2). Shilling percentage was estimated as following formula: Shilling (%) = (seeds weight/pods weight) X 100

Nutritional value of seeds: Macro; (Ca, K, Mg and N; in %) and microelements (Cu & Zn in ppm) constituents in dried seeds were defined. Total nitrogen was determined using micro-Kjeldahl method as stated in AOAC[35]. Potassium content was determined using a flame photometer. Cupper, Magnesium and Zinc were determined using the Atomic absorption spectrophotometer (Perkin Elemer 100 B).

Statistical analysis: Data were statistically analyzed via an analysis of variance (ANOVA) of Completely Randomized Design using M-Stat program (MSTAT-C v. 3.1., 1988) [32]. Least Significant Difference ($LSD_{5\%}$) was implemented to compare mean values. Also data of nutritional value of yielded seeds was statistically analyzed by Independent *t*-test using SPSS program Version 16.

3. Results

3.1. Laboratory experiment

Seed germination traits: Tables 3 & 4 and Plate 1 display that significant elevations were recorded concerning the application of various magneto-priming seed treatments (T_1-T_5) compared to untreated ones on germination and seedling traits. As an average of all magneto-priming treatments (T_1-T_5), the improvement in estimated parameters represented Seed Germination (G): 12.13%, Germination Index (GI): 12.13%, Speed Germination Index (SGI):15.83%, Germination Energy (GE):12.13% and Germination rate (GR): 2.88%.A similar positive impact was observed in Mean Germination Time (MGT; day) as the seeds were faster germinated by 8.99% compared to untreated seeds. Furthermore, Table 4 and Plate 1 exposed similar positive impacts concerning implementation of magneto-priming seed treatments (T_1-T_5) compared to untreated seeds. Also, as an average of all magneto-priming treatments (T_1-T_5), the improvements over untreated seeds were 26.95% in seedling length, 38.35% in seedling weight, 42.75% in seedling vigor-1 and 55.71% in seedling vigor-2.

Table 3.Impact of Magneto-priming seed treatments on Seed Germination parameters of ground nut at 12 days after germinated.

Character / Treatment	G (%)	GI	SGI	GE (%)	GR (day)	MGT (day)
Control	76.25	3.05	12.92	76.25	0.91	1.46
T_1	80.00	3.20	13.69	80.00	0.93	1.34
T_2	82.50	3.30	13.92	82.50	0.91	1.43
T_3	86.25	3.45	14.83	86.25	0.93	1.36
T_4	93.75	3.75	18.38	93.75	0.98	1.08
T_5	85.00	3.40	14.00	85.00	0.92	1.42
F test	**	**	**	**	**	**
$LSD_{5\%}$	**6.37**	**0.25**	**0.84**	**6.37**	**0.31**	**0.15**
± percentage (average of T_1-T_5) over control	**12.13**	**12.13**	**15.84**	**12.13**	**2.88**	**-8.99**

** significant at 0.01 probability according to F

Table 4.Impact of Magneto-priming seed treatments on seedling length (cm), seedling weight (g), seedling vigor-1 and seedling vigor-2 of groundnut at 12 days after days.

Character / Treatment	Seedling length (cm)	Seedling dry wt. (g)	Seedling vigore-1 (SV-1)	Seedling vigore-2 (SV-2)
Control	4.79	0.115	365.36	8.77
T_1	5.08	0.133	406.67	10.64
T_2	6.35	0.162	523.88	13.33
T_3	6.35	0.158	547.83	13.63
T_4	6.38	0.174	598.13	16.31
T_5	6.25	0.169	531.25	13.36
F test	**	**	**	**
$LSD_{5\%}$	**0.46**	**0.013**	**58.61**	**1.39**
+ percentage (average of T_1-T_5) over control	**26.95**	**38.35**	**42.75**	**55.71**

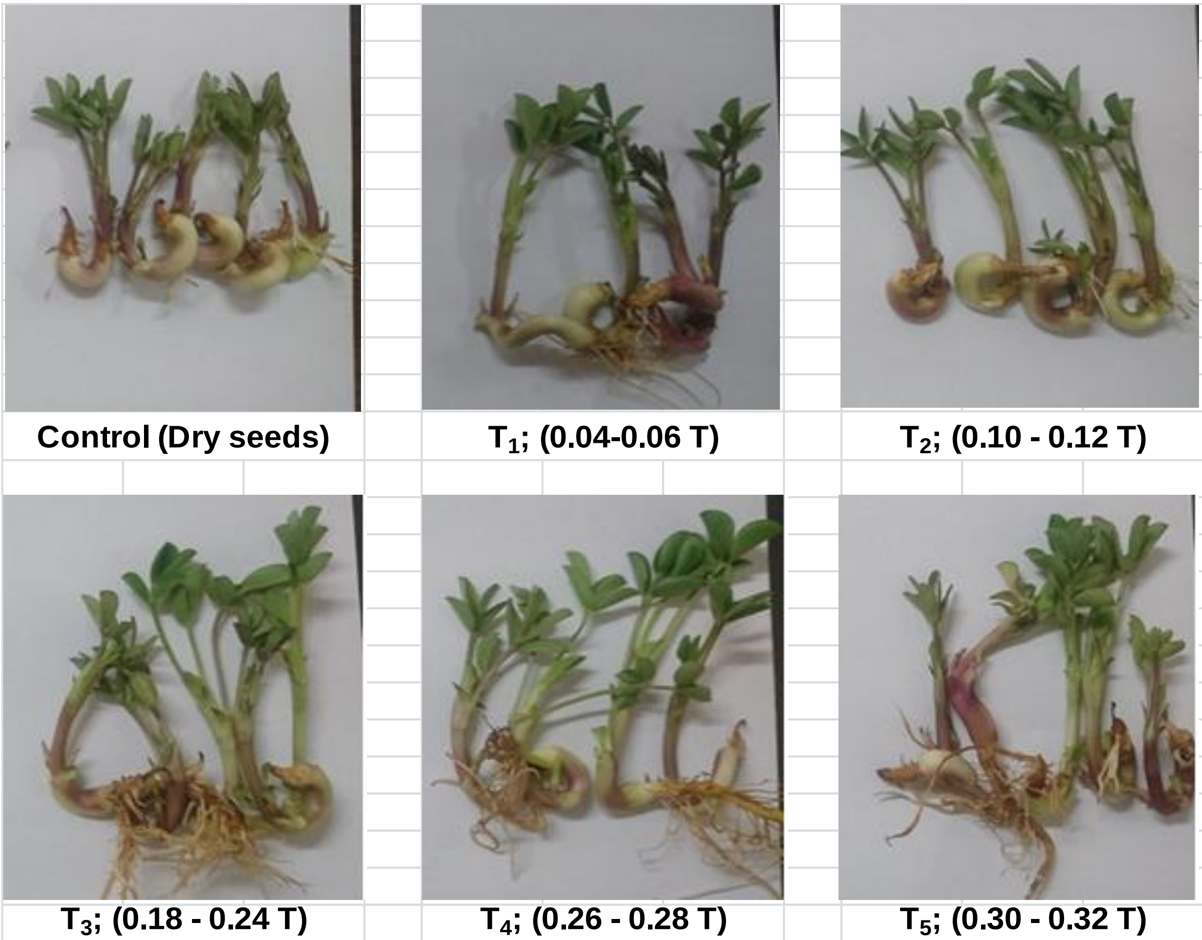

Plate 1. Impact of magneto-priming seed treatments on seedling growth of groundnut at 12 days post planting.

3.2 Field experiment:

3.2.1 Groundnut growth at 90 days post sowing:

Data represented in Table 5 and Plate 2 display that irrigation of groundnut plants with magnetized saline water under sprinkler or drip irrigation systems resulted in marked elevation in the groundnut growth at 90 DAS compared to irrigation with un-magnetized saline water. As the improvements, averages reached 9.76%, in plant height, and 14.9% in dry weight (g Plant^{-1}). As well as the improvement reached 15.97% in total chlorophyll (SPAD) at 90 DAS. Moreover, table 5 also revealed that the values of above growth indices were higher under drip than sprinkler irrigation systems. The progress ranged between 7.55-10.82%.

Table 5. Comparison between irrigation with magnetized and un-magnetized saline water under drip and sprinkler irrigation systems at 90 DAS (Average of 2021 and 2022 summer season).

Treatment / Character	Sprinkler irrigation		Drip irrigation		LSD at 5%
	Un-Magnetized saline water	Magnetized saline water	Un-Magnetized saline water	Magnetized saline water	
Plant height (cm; 90 DAS)	42.78	46.56	47.00	52.00	**2.35**
Dry wt. (g Plant^{-1};90 DAS)	46.44	53.22	50.00	57.19	**3.13**
Total ch. (SPAD; 90 DAS)	34.00	38.66	36.78	43.42	**1.64**

Irrigation with Un-Magnetized Water **Irrigation with Magnetized Water**

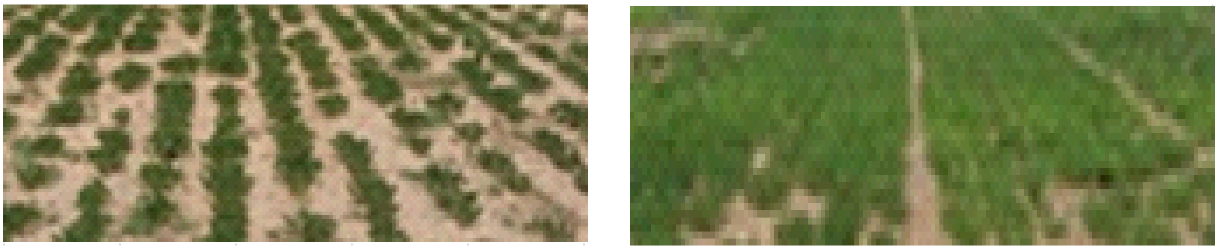

Plate 2. The compared growth of Groundnut under magnetized and un-magnetized saline water treatments at summer season in Nubaria region.

3.2.2 Groundnut yield and its components:

Data presented in Table 6 demonstrated that irrigation of groundnut plants with magnetized saline water under either sprinkler or drip systems elevated significantly the yield and yield components of groundnut compared to irrigation with un-magnetized one. The improvement averages reached 16.77% in plant height, 14.17 and 22.17% in branches and pods number per plant, respectively, 16.01% and 20.09 % in pods and seed weight (g plant^{-1}), 2.46% in 100-seed weight (g) and 3.65% in shilling percentage, respectively. These elevations were reflected in getting better seed, straw, and biological yields (ton fed^{-1}) by 20.26%, 16.25%, and 17.21%, respectively. Analogous trends were recorded in harvest and crop indexes where the improvements reached 2.46%, 7.00 and 3.12%, respectively compared to the control over both irrigation systems. Generally, the values of above groundnut yield and its components were higher under drip than sprinkler irrigation systems. The improvement scoped between 2.75 to 15.00%.

Table 6. Comparison between irrigation with magnetized and un-magnetized saline water under sprinkler and drip irrigation systems on groundnut yield components and production (ton fed^{-1}; fed=4200m^2) at summer harvest (Average of 2021 and 2022 summer season)

Treatment	Sprinkler irrigation		Drip irrigation		LSD at 5%
Character	Un-Magnetized saline water	Magnetized saline water	Un-Magnetized saline water	Magnetized saline water	
Plant height (cm)	41.78	46.56	47.00	57.11	**5.77**
Branches (no. Plant^{-1})	6.11	7.33	7.22	7.89	**0.97**
Pods (no. Plant^{-1})	27.33	31.65	28.71	36.81	**3.63**
Pods wt. (g Plant^{-1})	32.22	38.62	37.88	42.69	**1.06**
Seeds (no. Plant^{-1})	39.87	51.31	46.43	54.15	**4.22**
Seed weight (g Plant^{-1})	23.88	30.35	29.48	33.72	**0.32**
Shilling (%)	74.13	78.59	77.82	79.00	**2.25**
100-seed weight (g)	68.26	76.34	76.79	78.85	**1.68**
Seed yield (ton fed.$^{-1}$)	1.13	1.35	1.29	1.56	**0.12**
Straw yield (ton fed.$^{-1}$)	3.67	4.22	4.02	4.72	**0.30**
Biol. yield (ton fed.$^{-1}$)	4.80	5.58	5.31	6.28	**0.25**
Harvest index (%)	23.63	24.25	24.32	24.88	**ns**
Crop index (%)	31.01	32.02	32.16	33.12	**ns**

ns; no significant according F test

3.2.3 Nutritional value of output seeds

Crude protein, oil percentage, macro elements (Ca, K, Mg, and N; in percen), and microelement contents (Cu and Zn in ppm) contents in dried seeds were elevated due to the implementation of magnetized irrigation water compared to untreated ones. The elevation reached to 3.16%, 4.85%, 3.16%, 3.48%, 12.12%, 11.21%, 5.56% and 7.69% in the above-mentioned indices, respectively (table 7).

Table 7.Comparison between irrigation with magnetized and un-magnetized saline water under drip irrigation system on nutritional value of groundnut seeds (Average of both summer seasons 2021 &2022).

	Treatment / Character	Mean: Un-Magnetized saline water (control)	Mean: Magnetized saline water	*p-value*	Increase or decrease % over control
Nutritional value of yielded seeds	**Oil (%)**	43.34	44.71	*	3.16
	N (%)	6.93	7.15	*	3.16
	Crude protein (%)	24.46	25.65	**	4.85
	K (%)	1.15	1.19	ns	3.48
	Ca (%)	0.017	0.019	*	12.12
	Mg (%)	0.05	0.06	ns	11.21
	Na (%)	0.071	0.067	ns	-5.16
	Zn (ppm)	39.00	41.17	ns	5.56
	Cu (ppm)	6.50	7.00	ns	7.69

n= 3; ns= no significant; *, ** are significant at 0.05 and 0.01 probability according to independent *t*-test

4. Discussion

Germination is considered a critical phase in seedling stage and plays a vital role in crop yield. The germination process involves two obvious stages; the first is imbibition, particularly relying on the physical merits of the seeds. While the second is a heterotrophic growth stage lies between imbibition and emergence [36]. The impact of magneto-priming of seed treatments on germination and growth ~~is~~ prevalent in numerous plants. Current study was performed to determine the impact of magneto-priming seeds and magnetically treated saline water either under sprinkler or drip irrigation system on seed germination, seedling growth, chlorophyll content, and yield of groundnut productivity. Magnetically treated saline water created positive impacts on all studied parameters compared to non-magnetized saline water irrigation. The stimulatory impacts of magnetized water on germination and seed vigour of groundnut seeds may be referred to the ameliorated water quality and boosted enzymatic performances which are substantial during germination, seedling growth and development. Water ~~has~~ fundamental role in chemical reactions at cellular organelles, and acts as a mediator of ionic species rather than carbohydrates and protein metabolism [37]. In this concern, the rapid transportation of water and energy inside the cell in response to magnetic field treatments caused alteration in cell membrane permeability [38] and boost the metabolic pathways [39]. Magnetized water induced marked change in the biochemical, metabolic, and physiological performances because of higher enzymatic activities, that are responsible for promoted germination and rapid seedling growth [40]. Additionally, Abu-Muriefah [41] mentioned that hydro-priming, with hormones, improve considerably the germination of soybean seeds because water itself may act as a germinator, stimulating primer and in the absence of plant hormones it might lead to the getting better of seed germination. Numerous studies have pointed out that magnetized water is potent for enhancing crop seed quality and efficient for the activation of germination and seedling growth. They are concentrated on the determination of magnetic field impacts on physiological (germination), morphometric (early seedling growth) and structural (changes in seed coat surface) parameters [42-45]. Furthermore, the impact of the magneto priming seeds treatments on different seeds of plants, constituted significant improvement of seeds germination and the vigour of the low viability seedlings. Researchers also added that seeds treated with magnetic fields absorbed more moisture and contained higher albumin, gluten, starch contents and increased yield and fibre length [46]. Concerning the effect of irrigation method on growth, total chlorophyll, yield and yield components of groundnut plants, the results displayed that drip irrigation overcomes sprinkler irrigation in all studied indices. Also magnetized water promoted all studied criteria of groundnut plants irrigated either with drip or sprinkler as compared with plants irrigated with non-magnetized water. The same trend was mentioned by [47] who stated that the high sunflower yield in response to drip irrigation was attributed to particular irrigation management that causes a radial distribution manner and effective nutrient fertigation in the wetted soil volume. The plurality of the roots is connected near the emitter or along each lateral line. Also, [48] mentioned that the elevation in maize production due to drip irrigation was explained by the higher uniformity of irrigation, easy availability of water within the root zone, and lowering evaporation losses from soil. Moreover, [49] stated that, drip irrigation system caused the highest values of all yield indices (seed weight/plant, 100-seed weight, seed yield/fed. and head diameter) of sunflower as compared with the sprinkler irrigation system. Commonly, groundnut yield and its components were elevated in response to irrigation with magnetized water as compared to plants grown under un-magnetized water. These data are harmonized with those concluded by abundant authors [15, 19, 50-53] on numerous crops. The agronomic implementation of magnetic fields (MFs) in plants has revealed the potential to alter classical plant production systems, elevating mean germination rates, root and shoot growth. In addition to high productivity, elevating photosynthetic pigment content and emphasizes cell division, as well as nutrient and water utilization. An improved realization of the interactions between the MFs and the plant responses could revolutionize crop yield via raised resistance to stress circumstances, as well as the superiority of nutrient and water uptake, leading to the improvement of crop production [54]. Furthermore, the application of magnetized water technology can reduce the injury impacts of salinity stress. So, magnetically treated water can enhance crop and water productivity [55].

Conclusion

Under similar circumstances of experiments, it could be concluded that implementation of magnetized water and seed technology mitigates salinity water stress, which leads to improvement of growth and productivity of groundnuts in Nuberia region. Further, drip irrigation is the most pronounced than sprinkler irrigation.

Conflicts of Interest:

The authors declare no conflict of interest

References

[1] Gulluoglu, L., Bakal, H., Onat, B., El-Sabagh, A., and Arioglu, H. Characterization of peanut (*Arachishypogaea*L.) seed oil and fatty acids composition under different growing season under Mediterranean environment. Journal of Experimental Biology and Agricultural Sciences, 4(5 Suppl.), 564-571 (2016).DOI:http://dx.doi.org/10.18006/2016, 4(5S):564-571.

[2] Hefny, Y. A., and Safina, S. A. Evaluation of intercropping groundnut (*Arachishypogaea* L.) with maize under different plant densities in sandy soils. Egyptian Journal of Agronomy, 39 (1), 9-18. (2017). doi: 10.21608/agro.2017.486.1050

[3] FAOSTAT, Food and Agriculture Organization of the United Nations Statistics Division. FAOSTAT—FAO's Corporate Statistical Database; Economic and Social Development Department, FAO: Rome, Italy, 2019; Available online: http://faostat3.fao.org/ home/E (accessed on 15 February 2021).

[4] Vanlauwe, B., Descheemaeker, K., Giller, K. E., Huising, J., Merckx, R., Nziguheba, G., and Zingore, S. Integrated soil fertility management in sub-Saharan Africa: unravelling local adaptation. SOIL, 1(1), 491-508 (2015).

[5] Jaiswal, S. K., Msimbira, L. A., and Dakora, F. D. Phylogenetically diverse group of native bacterial symbionts isolated from root nodules of groundnut (*Arachishypogaea* L.) in South Africa. Systematic and applied microbiology, 40(4), 215-226 (2017).

[6] Variath, M. T., and Janila, P. Economic and academic importance of peanut. The peanut genome, 7-26 (2017).Springer, Cham.https://doi.org/10.1007/978-3-319-63935-2_2

[7] Seadh, S. E., Abido, W. A. E., El-Al, A., and Ibrahim, Z. A. A. Effect of Npk-Levels on Productivity and Seed Quality of Some Groundnut Genotypes under Newly Reclaimed Sandy Soils Conditions. Journal of Plant Production, 8(5), 605-609 (2017).

[8] Boydak, E., Simsek, M., and Demirkiran, A. The Effects of Different Irrigation Levels and Nitrogen Rates on Peanut Yield and Quality in Southeastern Anatolia Region of Turkey. KSU TarimVeDogaDergisi-Ksu Journal Of Agriculture And Nature, 24(2), 306-312 (2021).https://doi.org/10.18016/ksutarimdoga. vi.76348

[9] L. S. Pereira, I. Cordery, I. Iacovides, Coping with Water Scarcity. Addressing the Challenges.Springer, Dordrecht, 382 (2009).

10] Zaccaria, D., Oueslati, I., Neale, C. M., Lamaddalena, N., Vurro, M., and Pereira, L. S. Flexible delivery schedules to improve farm irrigation and reduce pressure on groundwater: A case study in southern Italy. Irrigation science, 28, 257-270 (2010).

[11] Cetin, O., and Bilgel, L. Effects of different irrigation methods on shedding and yield of cotton. Agricultural Water Management, 54(1), 1-15 (2002).

[12] Gireshsingh, M., and Mahindra, C. A study on the effects of different irrigation methods and Fertilizer regimes on groundnut (*Arachis hypogea* var. cabri). Scholars Journal of Agriculture and Veterinary Sciences, 3(1), 9-19s. (2016).

[13] Shoman, H., and Bughdady, A. Effect of irrigation systems and calcium on productivity and quality of peanut (*Arachishypogaea* L.) at New Valley. Journal of Plant Production, 9(4), 321-326 (2018) DOI: 10.21608/jpp.2018.35694.

[14] Mohamed, M. F., Maha, M. S. A., Khalifa, R. K. M., Ahmed, A. G., and Hozayn, M. Effect of arginine and GA3 on growth, yield,

mineral nutrient content and chemical constituents of faba bean plants grown in sandy soil conditions. International Journal of ChemTech Research, 8(12), 187-195 (2015).

[15] Hozayn, M., El-Bassiouny H. M. S., Abd El-Monem A. A., and Abdallah, M. M. Applications of magnetic technology in agriculture, a novel tool for improving water use efficiency and crop productivity:2. Wheat International Journal of ChemTech Research, 8 (12), 759-771 (2015).

[16] Hozayn, M. Abd El-Wahed, M.S.A. Abd El-Monem, A.A. Abdelraouf, R.E., and AbdElhamid, E.M. Applications of magnetic technology in agriculture, a novel tool for improving water and crop productivity: 3. Faba bean Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7(6), 1288-1296 (2016).

[17] Hozayn, M., Abd El-Monem, A.A., and Elmahdy, A.A. Application of magnetic technology for salinity stress mitigation and improving sunflower productivity under South Sinai conditions. Middle East Journal of Agriculture Research.6(4), 1490-1500 (2017).

[18] Hilal, M. H., and Hilal, M. M. Application of magnetic technologies in desert agriculture. 1.-seed germination and seedling emergence of some crops in a saline calcareous soil.Egyptian Journal of Soil Science (Egypt), 40(3), (2000).

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

[20] Hozayn, M., Lateef, E. M. A., Sharar, F. F., and Monem, A. A. A. Potential uses of sorghum and sunflower residues for weed control and to improve lentil yields. Allelopathy Journal, 27(1), 15-22 (2011).

[21] M. Hozayn, A. A. Ramadan, F. M. Elkady and A. A. Abd El-Monem, Protective effects of magnetic water technology in alleviating salinity stress on growth, yield and biochemical changes of barleY (*Hordeumvulgare*, L.). PCBMB; 21(37-38):149-65, 2020. Available from: http://www.ikprress.org/index.php/PCBMB/article/view/5426.

[22] Hozayn, M., Elaoud, A., AttiaAbd El-Monem, A., and Ben Salah, N. Effect of magnetic field on growth and yield of barley treated with different salinity levels. Arabian Journal of Geosciences, 14(8), 701 (2021).https://doi.org/10.1007/s12517-021-07077-4

[23] Esmaeilnezhad, E., Choi, H. J., Schaffie, M., Gholizadeh, M., and Ranjbar, M. Characteristics and applications of magnetized water as a green technology. Journal of Cleaner Production, 161, 908-921 (2017).

[24] Moosavi, F., and Gholizadeh, M. Magnetic effects on the solvent properties investigated by molecular dynamics simulation. Journal of Magnetism and Magnetic Materials, 354, 239-247 (2014).

[25] El-Zawily, A. E. S., Meleha, M., El-Sawy, M., El-Attar, E. H., Bayoumi, Y., and Alshaal, T. Application of magnetic field improves growth, yield and fruit quality of tomato irrigated alternatively by fresh and agricultural drainage water. Ecotoxicology and environmental safety, 181, 248-254 (2019).

[26] ISTA. International rules for seed testing. International Seed Testing Association (ISTA), Seed Science and Technology, 27, Supplement, 1999.

[27] International Seed Testing Association. International rules for seed testing. Rules 1985.Seed science and technology, 13(2), 299-513. (1985).

[28] Ruan, S., XUE, Q., and Tylkowska, K. The influence of priming on germination of rice (*Oryzasativa* L.) seeds and seedling emergence and performance in flooded soil.Seed science and technology, 30(1), 61-67 (2002).

[29] AOAC, Official Methods of Analysis, 17th Ed. Association of Official Analytical Chemists,Washington, DC, USA, (2000).

[30] Bartlett, M. S. Some examples of statistical methods of research in agriculture and applied biology. Supplement to the Journal of the Royal Statistical Society, 4(2), 137-183 (1937).

[31] ELLIS, R. The quantification of agent and survival in orthodox seeds. Seed Sci. Technol., 9, 373-409 (1981).

[32] MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University, East Lansing (1988).

[33] Chapman, H. D., & Pratt, P. F. Methods of analysis for soils, plants and waters. Soil Science, 93(1), 68 (1962).

[34] Konica, M. O. Chlorophyll Meter SPAD-502Plus - A lightweight handheld meter for measuring the chlorophyll content of leaves without causing damage to plants (2012). URL:http://www. konicaminolta. Com /instruments/ download/catalog /color/ pdf/ spad 502plus_e1.pd f

[35] Association of Official Seed Analysis, A. O. S. A. Rules for testing seeds. J. Seed Technol. 12: 18-19, (1991).

[36] Hozayn, M. Ahmed, A. A. El-Saady A. A., and Abd-Elmonem, A.A. Enhancement in germination, seedling attributes and yields of alfalfa (*Medicagosativa* L.) under salinity

stress using static magnetic field treatments. Eur. J. Biosci. 13(1), 369–378 (2019).

[37] Iqbal, M., and Bhatti, I. A. Gamma radiation/H2O2 treatment of a nonylphenolethoxylates: degradation, cytotoxicity, and mutagenicity evaluation. Journal of hazardous materials, 299, 351-360 (2015).

[38] Reina, F. G., Pascual, L. A., and Fundora, I. A. Influence of a stationary magnetic field on water relations in lettuce seeds. Part II: experimental results. Bioelectromagnetics: Journal of the Bioelectromagnetics Society, The Society for Physical Regulation in Biology and Medicine, The European Bioelectromagnetics Association, 22(8), 596-602 (2001).

[39] M. Iqbal, D. Muhammad, Zu. Haq, J. Yasir, A. M. Raza, Effect of pre-sowing magnetic field treatment to garden pea (*Pisumsativum* L.) seed on germination and seedling growth. Pakistan Journal of Botany.44(6), 1851–1856 (2012).

[40] ulHaq, Z., Iqbal, M., Jamil, Y., Anwar, H., Younis, A., Arif, M., and Hussain, F. Magnetically treated water irrigation effect on turnip seed germination, seedling growth and enzymatic activities. Information processing in agriculture, 3(2), 99-106 (2016).

[41] Abu-Muriefah, S. S. Phytohormonal priming improves germination and antioxidant enzymes of soybean (*Glycine max*) seeds under lead (Pb) stress. Bioscience Research, 14(1), 42-56 (2017).

[42] Maffei, M. E. Magnetic field effects on plant growth, development, and evolution. Frontiers in plant science, 5, 104293 (2014).

[43] Misra, N. N., Schlüter, O., and Cullen, P. J. (Eds.). Cold plasma in food and agriculture: fundamentals and applications. Academic Press. (2016).

[44] Sera B. and Sery, M. Non-thermal plasma treatment as a new biotechnology in relation to seeds, dry fruits, and grains. Plasma Science and Technology, 20(4), 044012 (2018).

[45] Mildažienė, V., Aleknavičiūtė, V., Žūkienė, R., Paužaitė, G., Naučienė, Z., Filatova, I., and Baniulis, D. Treatment of common sunflower (*Helianthus annus* L.) seeds with radio-frequency electromagnetic field and cold plasma induces changes in seed phytohormone balance, seedling development and leaf protein expression. Scientific reports, 9(1), 6437 (2019).

[46] Carvajal-Flórez, E., and Cardona-Gallo, S. A. Technologies applicable to the removal of heavy metals from landfill leachate. Environmental Science and Pollution Research, 26, 15725-15753 (2019). https://doi.org/10.1007/s11356-019-04888-7.

[47] Abdel-Latif, I. A., Ismail, A. A., Bouzid, H., andAl-Hajry, A. Synthesis of novel perovskite crystal structure phase of strontium doped rare earth manganites using sol gel method. Journal of Magnetism and Magnetic Materials, 393, 233-238(2015).https://doi.org/10.1016/j.jmmm.2015.05.078.

[48] Valentín, F., Nortes, P. A., Domínguez, A., Sánchez, J. M., Intrigliolo, D. S., Alarcón, J. J., and López-Urrea, R. Comparing evapotranspiration and yield performance of maize under sprinkler, superficial and subsurface drip irrigation in a semi-arid environment. Irrigation Science, 38, 105-115 (2020).https:// doi.org/10.1007/s00271-019-00657-z

[49] Ahmed, A. A., Aboelkassem, K. M., and Elnenny, E. M. M. Effect of sprinkler and drip irrigation systems on seed yield and quality of oil for some sunflower genotypes. SVU-International Journal of Agricultural Sciences, 3(3),96-107(2021). doi:10.21608/svuijas.2021.74407.1107

[50] Alderfasi, A. A., Al-Suhaibani, N. A., Selim, M. M., and Al-Hammad, B. A. A. Using magnetic technologies in management of water irrigation programs under arid and semi-arid ecosystem. Journal of Advances in Plants and Agriculture Research, 3(4), 1-7 (2016).

[51] Selim, A. F. H., and Selim, D. A. Physio-biochemical behaviour, water use efficiency and productivity of wheat plants exposed to magnetic field. Journal of Plant Production, 10(2), 185-191 (2019).

[52] Said, A. A., Motawea, M. H., Abdel-rahman, M. H., and Fawzy, Y. The effect of saline water magnetization on physiological and agronomic traits of bread wheat genotypes.SVU-International Journal of Agricultural Sciences, 2(2), 384-400 (2020).

[53] Rahimian, M. H., and Zabihi, H. R. Investigation of the Reaction of Potato Plant to Magnetized Saline Water. Agrotechniques in Industrial Crops, 1(3), 149-153 (2021).doi: 10.22126/atic.2022.7145.1025

[54] Sarraf, M., Kataria, S., Taimourya, H., Santos, L. O., Menegatti, R. D., Jain, M., and Liu, S. Magnetic field (MF) applications in plants: An overview. Plants, 9(9), 1139 (2020).

[55] Dastorani, M., Albaji, M., and Nasab, S. B. A comparison of the effect of magnetic drip irrigation and conventional irrigation with different salinity levels on the yield and yield components of sunflower (*Helianthus annuus*L.). Arabian Journal of Geosciences, 15(12), 1116 (2022). https://doi.org/10.1007/s12517-022-10126-1