Effect of Magnetized Water on Water Uptake, Germination and Seedling Growth of Four Plant Species

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Abstract

Water salinity influences seeds germination and seedlings growth of many plants. Water absorption as important issue of seeds germination for metabolic processes is also affected by water salinity. This study was conducted to determine the effect magnetized water on water absorption, seeds germination and seedling parameters of wheat (Triticum aestivum), barley (Hordeum vulgare), trigonella (Trigonella foenum-graecum), and

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lentil (Lens culinaris M) plants under fresh and low saline water condition. Seeds of each plant were treated with fresh water (control) and magnetized water (MW) or non- magnetized water (NMW) low saline water at germination stage of plant growth. A complete randomized design (CRD) experimental layout was used and each treatment was replicated four times given a total of 48 samples. The result of the study indicated that water uptake percentage of seeds treated with magnetized water were all higher than the values of water absorption from non-magnetized water. Also, the result showed that treating seed of plants during germination with magnetized water improved germination and related parameters, include water uptake percentage, speed of germination, seedling length, fresh weight, dry weight and vigor index of all plants included in this study with respect to the control treatment. This indicated that seeds of plants treated with magnetized water absorbed more water from the medium easily and grew faster than the seeds of plant treated with non- magnetized water. The study concluded that treating seeds with magnetized water may has the beneficial effect in improving germination parameters and biomass accumulation in wheat, barley, trigonella, and lentil plants. However; further investigations are needed under field conditions.

Key words: *Magnetic water; germination; water uptake; wheat; trigonella; barley lentil.*

1. Introduction

Water salinity is an ecological stress aspect that reduces growth and yield of different crops in many regions of the world. Because of the limited fresh water resources, it's important to use the available water resources which may have low or medium salinity level for irrigation.

One way to be able to get used of low or medium salinity level for irrigation is magnetically treated water. In agriculture sector magnetized water (MT) has been of great interest of may crop producers due to its low cost, easy to apply, and it been reported to be the most efficient and environmentally clean methods (Bogatin *et al*., 1999). Also, the use of magnetized water is safe, environmentally friendly and sustainable. That's because this method does not generate wastes, does not cause any harmful effect and does not require power. It has been reported that magnetized water may causes a change of water properties, and that water molecules becomes more dynamic and abler to flow (Tai *et al*., 2008). Magnetized water has been reported to effect water physical properties such as changing in surface tension of water (Amiri and Dadkhah, 2006). Also, the hydrogen bound of water molecule was found to be affected by magnetic treatments. Chang and Weng (2008) found that the magnetic treatment of a NaCl solution increased the hydrogen bonds, improved the movement of the ions and also reported that under low concentration solution the hydrogen bonding ability is improved as the magnetic field is increased (Chang and Weng, 2008). Magnetized water decreases flow losses in drip emitters (Aali *et al*., 2009). In addition, magnetic treatment of irrigation water has proved to influence the rate of chemical reactions, the precipitation of salts, the concentration of ions, soil pH, the electrical conductivity and soil soluble salts removing (Zúñiga, *et al*., 2016; Hachicha *et al*., 2018; Kozyrskyi *et al*., 2019). Moreover, magnetized water increases the movement of some ions in the soil solution. A study found that using magnetized water for soil leaching significantly increased the availability of soil P content (Mohamed and Ebead, 2013), and may changes in the moisture of soil profile (Khoshravesh *et al*., 2011).

Regarding the effect of magnetized water on seeds germination and on plant growth, there were many researches and works have been done and found that magnetized water had a positive effect on all stages of plant growth. Magnetized water may cause an improvement in seed germination, and in seedling traits of many plans. One study found that magnetized water is more easily absorbed by the seeds and can stimulate internal metabolic processes which are contributing to germination (Sudsiri *et al*., 2016). The same trend was found and indicated that magnetized water enhanced the germination percentage, effect germination rate, and improved seedling traits such as shoot and root length, seedling fresh and dry weight, and seedling vigor index (Ijaz *et al*., 2012; Al-Mashhadani *et al*., 2016; Massah *et al*., 2019).Improving germination percentage, germination speed, seedling traits and seedling vigor of seeds by magnetized water is an excellent option to consider if there are not high quality water available or poor soils. In addition, Magnetic treatment of irrigation water induced some biochemical changes and stimulated plant growth related reactions (Rawabdeh *et al*., 2014; Ali *et al*, 2019). Also, magnetic treatment of irrigation water found to be influenced the quality and nutrition value of some plants as study showed that magnetized water increased vitamins A and C in tomato plant (Yusuf and Ogunlela, 2017). While the positive effects of magnetized water on germination and growth of some plant species were well addressed, some other plant species have not investigated well to address the effect of magnetized water on germination and growth of these plants under salinity stress. Therefore; the aim of this study was to evaluate and highlight the effect of magnetized water on germination and plant growth traits of some Libyan crops such as wheat, barley, trigonella, and lentil plants.

Material and Methods:

This study was conducted in controlled environment facilities at the plant science department, university of Zawia. Experiments were conducted in fall of 2019 to determine the impact of irrigation by magnetized water on seed germination and seedling traits of wheat, barley, trigonella, and lentil plants. Seeds of local wheat, barley obtained from Libyan National GenBank in Tajoura, and trigonella, and lentil seeds obtained from the local market were used in this study. Magnetized water was obtained from Mr. Nordeen Albishty's farm located in Zawia city. the water in this farm is magnetized using delta water magnetic device with (14500 gause).

Experimental and Treatment Conditions:

A Petri dishes experiment based on randomized complete design (RCD) with four replications was employed. Healthy seeds of each plant were first sterilized with 3% sodium hypochlorite for 3 minutes, then washed twice in tape water and air dried. Then seeds were weighted (5g) and subjected to corresponding treatments following fresh water [EC] value of < $0.7 dSm^{-1}$control) and magnetized water MW or non-magnetized water NMW low saline water [EC] value of 5 dSm^{-1}). Seeds allowed for water imbibitions for 12h. After 12h seed weight was retaken. Then A total number of 48 Petri dishes were used with 20 seeds in each Petri dish. Fresh water and MTW or NMTW low saline water was applied to the corresponding samples. and the following three treatments are applied in four replications of each treatment, and following the modified method of (Krishnaraj *et al.*, 2017) the treatments applied as following:

1. Fresh water (control) in which initial of imbibitions of 12h, then seeds of each plant were sown in Petri dishes and kept at room temperature and in darkness for 8 days. Seeds were irrigated with fresh water from the time of sowing to the end of germination period.
2. Magnetized low saline water (MW) in which initial of imbibitions of 12h, then seeds of each plant were sown in Petri dishes and kept at room temperature and in the dark for 8 days. Seeds were irrigated with magnetized low saline water from the time of sowing to the end of germination period.
3. Non- magnetized low saline water (NMW) in which initial of imbibition of 12h, then seeds of each plant were sown in Petri dishes and kept at room temperature and in the dark for 8 days. Seeds were irrigated with non- magnetized low saline water NMW from the time of sowing to the end of germination period.

Data Collection:

`During the first 12h water absorption was calculated, the seeds were removed from the water, placed on filter paper and on surface dried with a tissue to reduce the excess water, then seeds were weighed and water uptake percentage (WUP)was determined as following the equation WUP = W2-W1/W1 x100 (Aghamir *et al.*, 2016).

WhereW1= initial weight of seed, and W2= weight of seed after absorbing water in a particular time.

Germination traits:

Germination per cent (G %) was expressed according to Nasri *et al.*, 2011. The following formula was used to calculate $G\ \% = (NSG \div TNSS) \times 100$

Where *NSG* is the number of seeds germinated. *TNSS* is the total number of seeds sown.

The germination speed (GS) was calculated according to the equation given by Rubio-Casal *et al*., (2003). The number of germinated seeds was recorded at 2 d interval from the start of sowing and last for 10 days and used to calculate GS. The following formula was used to calculate GS: $GS = n1/d1 + n2/d2 + n3/d3 + \cdots$

Where n_1 is the number of seeds germinated in day one of sowing, t_1 is the number of days taken for germination from day of sowing.

Mean daily germination (MDG) was calculated following Gairola *et al.,* (2011). The following formula was used to calculate MDG: $MDG = TNGS \div TNDG$

Where *TNGS* is the total number of germinated seeds and *TNDG* is the total number of days taken for final germination.

Early seedling traits:

Morphological traits viz., shoot and root length and fresh and dry weight were subsequently measured from 4 uniform seedlings from each treatment at early seedling stage. Selected seedlings were dissected and shoot, and root length were recorded. The length from the seed to the tip of the root and leaf blade was calculated to measure the root length and shoot length using meter scale, respectively. The fresh weight of seedling was recorded using a weighing balance, and then dried in an oven maintained at 50 °C till it attains stable weight. After that seedling dry weights were recorded. Using the morphological traits, seedling vigor index (SVI) were calculated. The following formula was used to calculate SVI (Aghamir *et al.,* 2016). *SVI* = (SDW x G%)/ 100

Where *SDW* is seedling dry weight and *G%* is germination percentage.

Statistical analysis:

The experimental design was a randomized complete design (RCD) with four replications. Analysis of variance performed using generalized linear model (GLM) procedure in SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for water uptake percentage, seed germination and related traits. Separation of means was carried out using the least significant differences (LSD; $P < 0.05$). The means were compared using Duncan's multiple range test.

Results:

The P-values for water uptake percentage, germination and seedling growth traits obtained with SAS PROC GLM are presented in table 1.

Variables			
Traits	Water Treatment (WT)	Plant Species (PS)	(WT xPS)
Germination percent (%)	<.0001	0.0036	0.0471
Mean daily germination	<.0001	0.0101	0.0694
Germination Speed (seed)	<.0001	0.0113	0.0435
Water uptake percentage (%)	<.0001	<.0001	0.0447
Shoot length (cm)	<.0001	<.0001	0.0496
Root length (cm)	<.0001	<.0001	0.0419
Seedling length (cm)	<.0001	<.0001	0.0369
Seedling fresh weight (g)	<.0001	<.0001	0.0487
Seedling dry weight (g)	<.0001	<.0001	0.0485
Seedling vigor index	<.0001	<.0001	0.0118

Table 1. Probability values of effects of water treatment (WT), plant species (PS), and WT x PS interaction on various germination and seedling characteristics traits

The independent effect of water treatment was highly significant (P <.0001) for water absorption, and all germination and seedling traits. The independent effect of plant species was highly significant (P < 0.01) for water uptake percentage, and all germination and seedling traits. Interaction effects of water treatment x plant species was significant (P < 0.05) for water absorption, and all germination and seedling traits except for mean daily germination (Table 1). Results of the independent effect of different water treatment on germination percentage, mean daily germination, germination speed, shoot length, root length, seedling fresh and dry weight and seedling vigor index are presented in (Tables 2). The result showed that water uptake percentage, germination and seedling traits were reduced under low saline condition as compared with the control (Fresh water), However; this reduction was less pronounced under low saline magnetized water than low saline non-magnetized water (Table 2)

Table 2. The main effect of different of water treatment (WT) on seed germination and seedling traits of four plant species. Data are averaged across four plant species, and four replications of each plant species. Means was estimated using the GLM procedure in SAS.

Traits	Fresh Water (FW)	Magnetized Water (MW)	Non- Magnetized Water (NMTW)
Germination percent (%)	98.8[a*]	94.4[b]	89.4[c]
Mean daily germination	6.6[a]	5.7[b]	4.8[c]
Germination Speed (seed)	9.6[a]	8.9[b]	8[c]
Water uptake percentage (%)	104[a]	91[b]	84[c]
Shoot length (cm)	7.3[a]	6.5[b]	6[c]
Root length (cm)	6.1[a]	5.3[b]	5[c]
Seedling length (cm)	13.5.[a]	11.8[b]	11[c]

Traits	Fresh Water (FW)	Magnetized Water (MW)	Non- Magnetized Water (NMTW)
Seedling fresh weight (g)	1.8[a]	1.6[b]	1.5[c]
Seedling dry weight (g)	0.62[a]	0.53[b]	0.46[c]
Seedling vigor index	0.61[a]	0.50[b]	0.42[c]

*Values followed by different letters are significantly different according to Duncan's multiple range test (*P < 0.05*).

The results of the response of different plant species to water treatments are presented in (Tables 2). The result showed that plant species responded differently to water treatments in terms of water uptake percentage, germination, and seedling traits (Table 3) Low saline water reduced water absorption seed germination, and seedling traits in all plant species. However, the result showed that lentil plants was the most effected plant species by water treatment as compared with other plant species included in this study (Table 3).

Traits	Wheat	Trigonella	Barley	Lentil
Germination percent (%)	95[a*]	94[a]	95[a]	92[b]
Mean daily germination	6[a]	5.4[b]	6[a]	5.5[b]
Germination Speed (seed)	9[a]	8.7[bc]	8.9[ab]	8.6[c]
Water uptake percentage (%)	62.5[c]	141[a]	52.8[d]	116[b]
Shoot length (cm)	8.7[a]	4.4[c]	8.5[a]	5[b]
Root length (cm)	7.5[b]	3.2[d]	7.7[a]	3.5[c]
Seedling length (cm)	16[a]	7.6[c]	16[a]	8.5[b]
Seedling fresh weight (g)	2[b]	1[d]	2.4[a]	1.2[c]
Seedling dry weight (g)	0.6[b]	0.3[d]	0.7[a]	0.4[c]
Seedling vigor index	0.65[b]	0.29[d]	0.69[a]	0.42[c]

Table 3. The main effect of plant species on seed germination and seedling traits of four plant species. Data are averaged across three water treatment and four replications. Means was estimated using the GLM procedure in SAS.

[*] Values followed by different letters are significantly different according to Duncan's multiple range test (*P < 0.05*).

Using magnetized water resulted in significant increase in water uptake by seeds. The result showed that water uptake percentage in all plant species was low under low saline condition as compared with fresh water (control). However, water uptake percentage was improved under magnetized water condition (Fig 1). After 2h, the seed water uptake of magnetized water was greater than the non- magnetized water (Fig 1). The result showed that plant species varied in their response to water treatments. In barley, wheat, trigonella, and lentil plants the reduction of water uptake under low saline untreated water was 12 %, 14 %, 20 %, and 24 % respectively as compared to control. Nevertheless, under magnetized water the reduction of water uptake under of barley, wheat, trigonella, and lentil was 5 %, 6 %, 13 %, and 17 % respectively as compared to the control (Fig 3A). In regard to seed germination and seedling traits, the results showed that final germination percentage of all plant species investigated in this study was slightly influenced by salinity. The final seed germination percentage of barley, wheat, trigonella, and lentil plants were reduced by 5 %, 8 %, 11 %, and 14 % respectively under low saline untreated water as compared with control (Fig 2A). Also mean daily germination was significantly influenced by salinity. The result indicated that mean daily germination deceased by 17 %, 19 %, 33 %, and 35 % in barley, wheat, trigonella, and lentil plants respectively under low saline untreated water as compared with fresh water (Fig 2B).

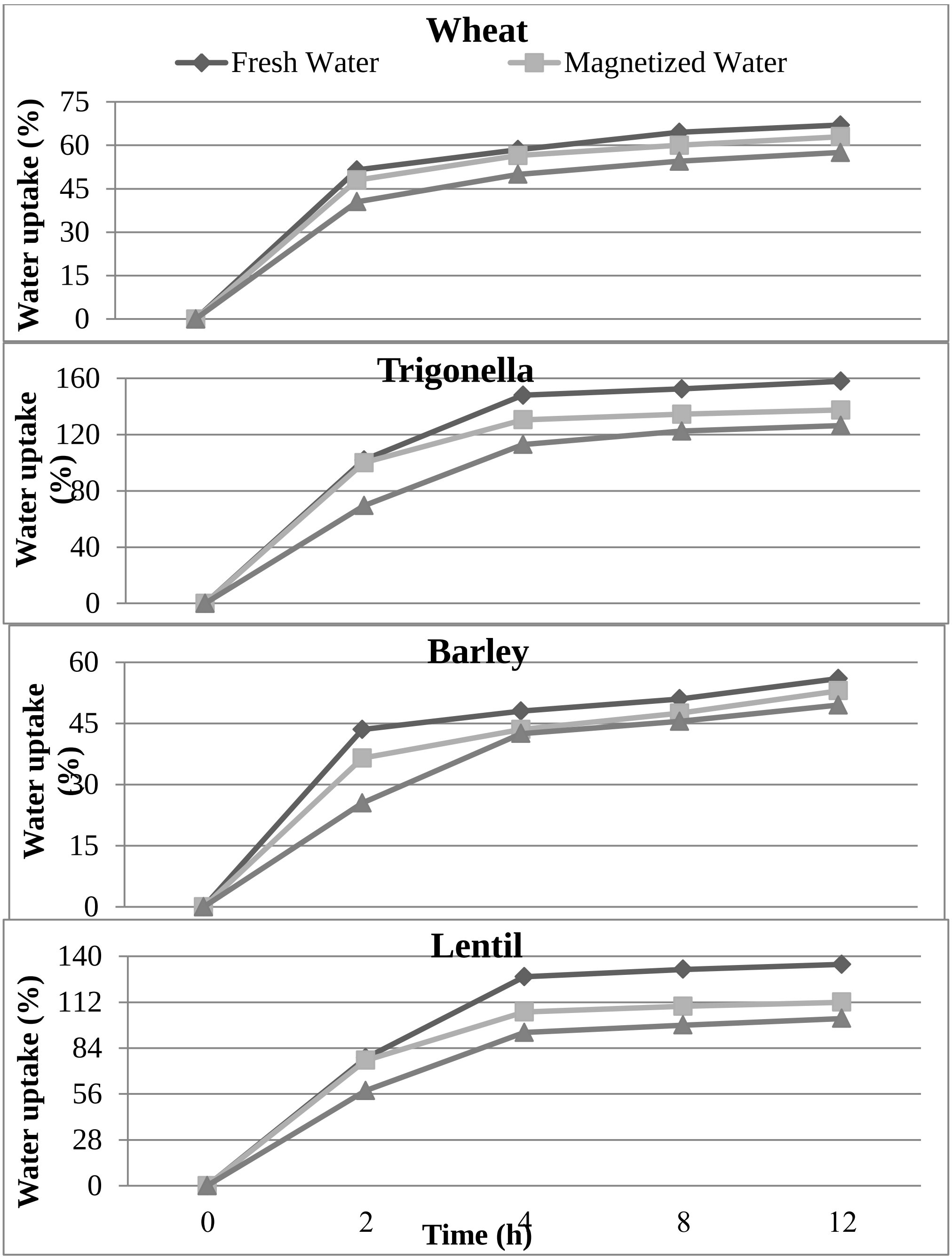
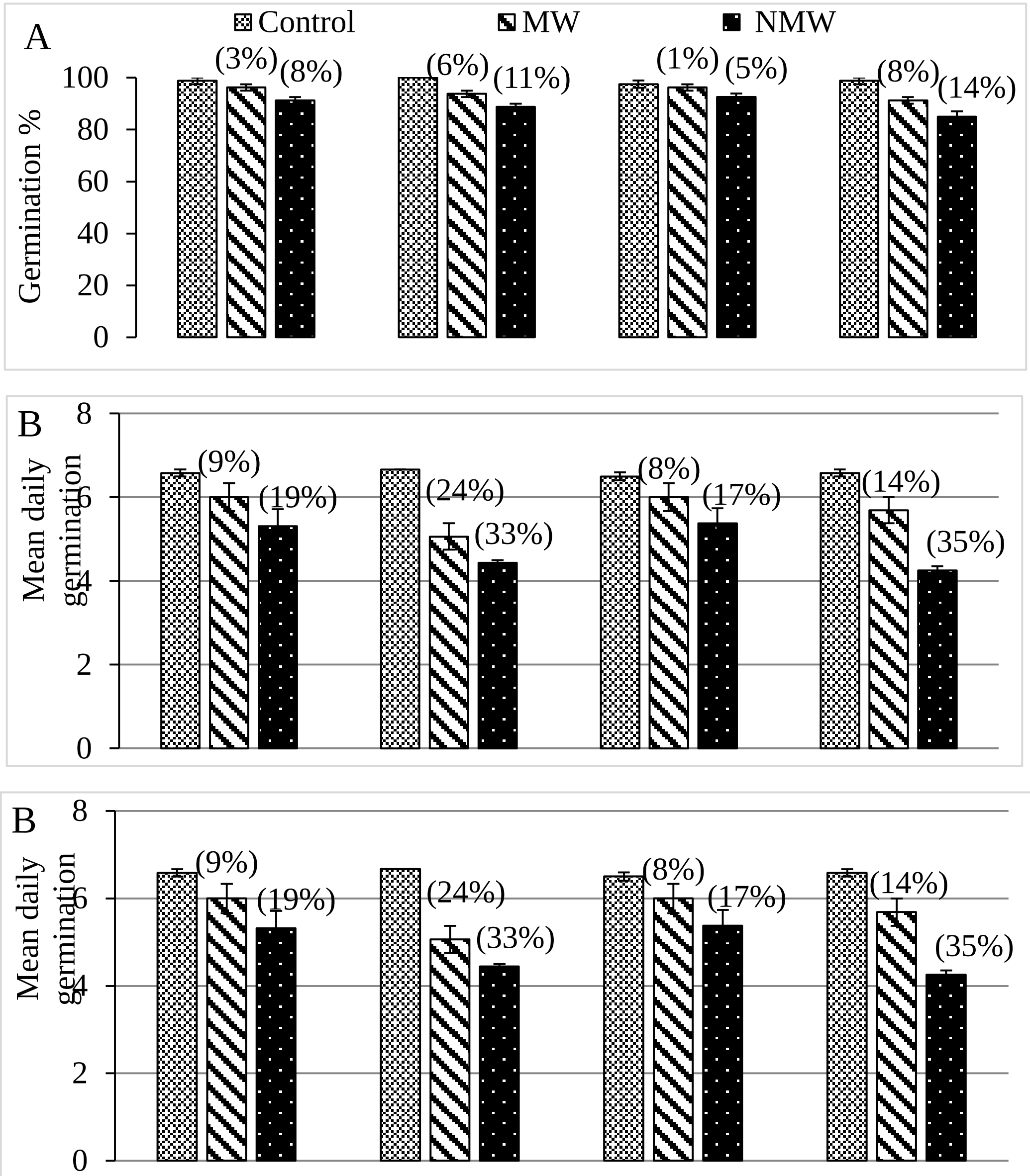


Figure 1. Water uptake percentage of four plant species as effected by water treatments.

In addition, germination speed dallied due to salinity stress. In barley, wheat, trigonella, and lentil plants the speed of germination reduced by 13 %, 13 %, 18 %, and 22 % respectively as compared to fresh water. However, magnetized water increased the germination speed of seedsin all plant species (Fig 2C).



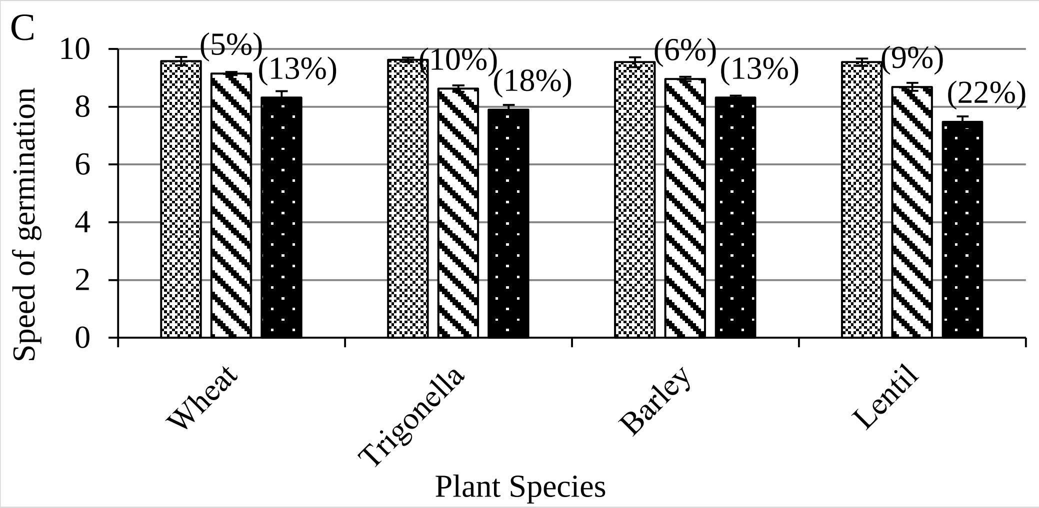
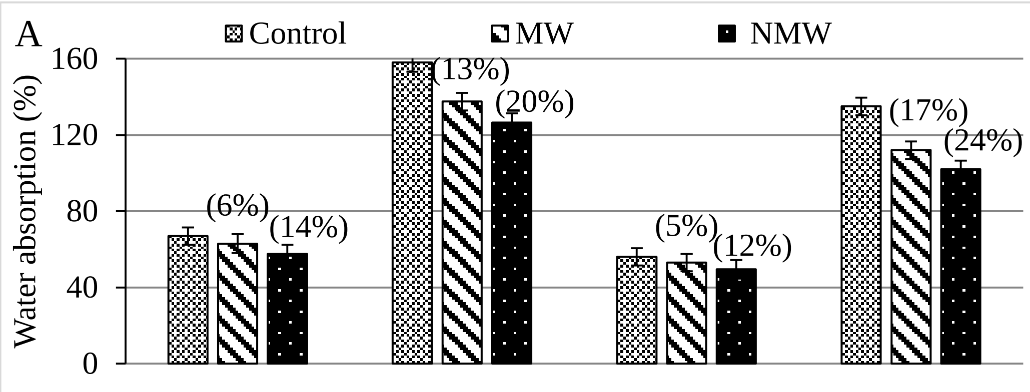


Fig 2. The effects of water treatments on (A) germination percentage, (B) mean daily germination and (C) speed of germination of four plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicates the percent reduction from control.

Moreover; magnetized water improved the seedling growth of all plant species tested in this study. Under low saline untreated water shoots and roots length of all plant species tested in this study were significantly affected (Fig 3 B, C). Though shoot and root length were improved at the low saline magnetized water.



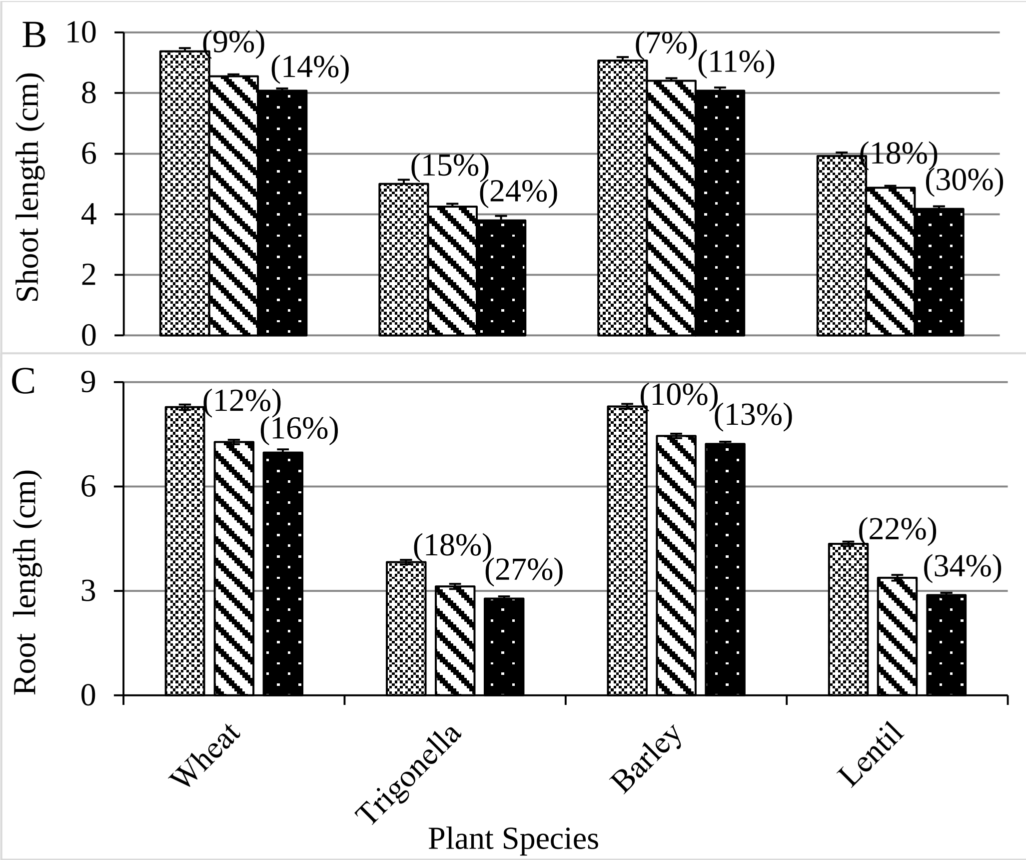


Fig 3. The effects of water treatments on (A) water absorption, (B) shoot length and (C) root length of four plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicates the percent reduction from control.

The result showed that the effect of low saline untreated water was more pronounced in root length than shoot length. In compression between shoot and root length reduction under saline non- magnetized water, shoot length in barley, wheat, trigonella, and lentil plants decreased by 11 %, 14 %, 24 %, and 30 % respectively. Whereas, root length reduced by 13 %, 16 %, 27 %, and 34 % in barley, wheat, trigonella, and lentil plants respectively (Fig 3 B, C).

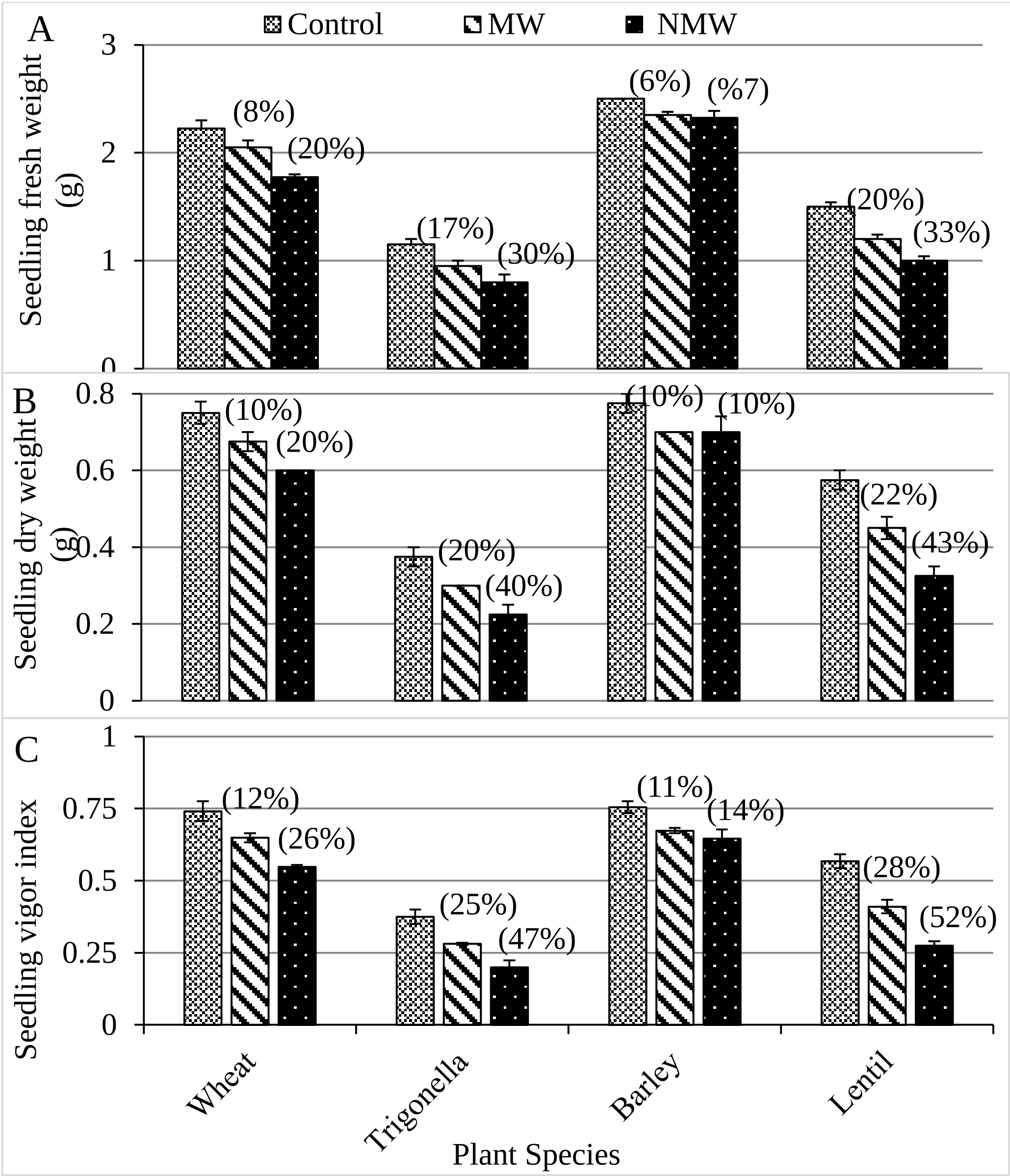


Fig 4. The effects of water treatments on (A) seedling fresh weigh, (B) seedling dry weigh and (C) seedling vigor index of four plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicates the percent reduction from control.

Magnetized water largely influenced the seedling growth and biomass production. The result reported that seedling fresh and dry weight decreased when seeds of plants treated with saline non-magnetized water as compared with fresh water and with saline magnetized water (Fig 4 A, B). In all plant species used in the study, seedling fresh and dry weight reduced under saline condition, however the dry weigh showed to be more sensitive to saline water than fresh weight except for wheat seedlings where both fresh and dry weight showed the same percent reduction over the control which was 20 %. Whereas in barley, trigonella, and lentil seedlings the percent reduction of fresh weigh over the control were 7 %, 30 %, and 33 % respectively, and the percent reduction of dry weigh over the control in barley, trigonella, and lentil seedlings were 10 %, 40 %, and 43% respectively (Fig 4A, B). The change of growth characters of the seedlings germinated under saline condition, seemed to affect seedling vigor index. The result indicated that seedling vigor index significantly influenced by water treatments. In fact, and due to magnetized water seedling vigor index was increased under saline condition as compared with non- magnetized water, the percent reduction of seedling vigor index in barley, wheat, trigonella, and lentil seedling under low saline magnetized water over fresh water were 11 %, 12 %, 25 %, and 28 % respectively. At the same time the percent reduction of seedling vigor index in barley, wheat, trigonella, and lentil seedling under low saline non- magnetized water over fresh water were 14 %, 26 %, 47 %, and 52 % respectively (Fig 4c).

Discussion:

It is clear that magnetized water showed better results than non-magnetized water under low salinity condition. Magnetized water was superior in improvement of water uptake, germination and seedling characteristic of studied plants through the direct and indirect effects of magnetized water. The study found that magnetic treated water led to stimulating and development of the seedlings of all plants included in the study, this finding similar to the finding of the effect of magnetized water on growth and yield of other plants such as common bean (Moussa, 2011), cucumber (Al-Shrouf, 2013),coffee plants (Alemán *et al.*, 2014), lettuce (Putti *et al.*, 2015), maize (Abedinpour and Rohani, 2016), tomatoes (Yusuf et al., 2016),Tabasco pepper (Ospina-Salazar et al, 2018), orchid (Aguilera et al 2018),and melon (Elaoud *et al.*, 2016; Aali *et al.*, 2009). In this study the magnetized water treatment increased seed water uptake and increased speed of germination, this was consistent with the results of previous studies (Mahmood and Usman, 2014; Krishnaraj *et al.*, 2017). Great increase in the water intake, germination and seedling growth this may be attributed to the suggestion that MTW changes its properties, like solubility and surface tension, so the water enter much easier to the internal parts of the seeds, which led to a better absorption and started up the metabolic processes that lead to germination. This finding support in early findings (Aghamir *et al.*, 2016; Sudsiri *et al.*, 2016; Yao and Shen, 2018). Results of this experiments revealed some beneficial effects of magnetized water under low saline condition. It has been reported that magnetic field treatment improved the soil and water quality such as total soluble solid and total dissolve solid (Khalil and Leila, 2016; UlHaq *et al.*, 2016). The result here in reported that the magnetized water treatment reduced the negative effects of salinity stress on seed germination and seedling characteristic. These results agree with several researchers who have reported that magnetized water treatment reduces negative effects of stress on plant growth (Azharonok *et al*., 2009; Liu and Shi 2013; Aghamir *et al*., 2016; Liu *et al*., 2019; Mahmoud *et al*., 2019).

Conclusions:

The study conclude that the magnetic treatment of irrigation water is an appropriate option where poor soils, water quality is low, high salinity level and unavailability of nutrients in the soil are presented such as in Libya. using magnetized water for irrigation in such condition could improve water use in crop production. However; more research and further investigation are needed to address the effect of such technique on plant growth and yields at different growth stages as well as diverse plant species.

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