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Abd El-Hady, M.
Water Relations and Field Irrigation Dept., National Research Centre, Egypt

H. A. Mansour
Water Relations and Field Irrigation Dept., National Research Centre, Egypt

A.E. Abdelghany
Water Relations and Field Irrigation Dept., National Research Centre, Egypt

Correspondence:
H. A. Mansour
Water Relations and Field Irrigation Dept., National Research Centre, Egypt

Improvement of Different Crop Seeds Germination through By Magnetized Saline Water Treated

Abd El-Hady, M., H. A. Mansour, A.E. Abdelghany

Abstract
Saline water is should be used, but there are many risks that are faced from planting to crop production if we used, (saltwater very expensive treatment costs). The aim of the present work is to design an electro-magnetic unit and evaluation of resulted magnetic force of different saline waters on the germination percentage and germination rate of different plant seeds i.e. (barley, sorghum, turnip, sunflower, and wheat) in laboratory.

The results indicated that any increase in magnetic force associated with improving germination %, especially wheat and sunflower followed by sorghum. Operating time of the uniformity test was one hour, germination percentage and germination rate estimated for known the validation of electro-magnetic device for its application in the laboratory experiments research work were 0.84; 89.92 % (345 ppm). This experiment was considered as a test study of the electro-magnetic device before the application at the open field.

Keywords: Magnetic unit, Saline water, Germination, Sunflower, Sorghum, uniformity

Introduction

Salinity is one of the most important abiotic stresses limiting crop production in arid and semiarid regions, where soil salt content is naturally high and precipitation can be insufficient for leaching (Neumann,1995), (Saboora, and Kiarostami, 2006). Salinity affects many morphological, physiological and biochemical processes, including seed germination, plant growth, and water and nutrient uptake (Willenborg*et al.* 2004). A prerequisite for successful production is a well stand establishment. One of the major environmental stress factors which adversely effect on uniform germination is salinity in arid and semi-arid regions (Demir, 2003). Many researchers have reported that several plants are sensitive to high salinity during germination and the seedling stage (Ghoulam, and Fares,2001). The source of the sensitivity to salinity is not fully understood. Some researchers have indicated that the main reason for germination failure was the inhibition of seed water uptake due to a high salt concentration (Mehmet, *et al.* 2006), whereas others have suggested that germination was affected by salt toxicity (Khajeh-Hosseini,*et al.*2003). Increasing irrigation water salinity significantly decreased plant length, shoot and root fresh and dry weights of faba bean. Besides the highest values for plant length shoot and root fresh and dry weights were observed when faba bean plants were irrigated with Ismailia canal water while the lowest values were observed with the irrigation with About Sewer well water (Ahmed and Bassem, 2013). Irrigation water quality can have a profound impact on crop production. All irrigation water contains dissolved salts, but the concentration and composition of the dissolved salts very depending on the source of the irrigation water (Maas and Grattan, 1999). Water is a major source for survival on this planet. Its conservation is therefore a priority. With the increase in demand, the supply needs to meet specific standards. Several purification techniques have been adopted to meet the standards. Magnetic separation is one purification technique that has been adapted from (Ambashta*et al.,* 2010) or (Ambashta and Sillanpää, 2010). Magnetic water is water that has been passed through a magnetic field. Magnetic water treatment devices are environmentally friendly, with low installation costs and no energy requirements. Magnetic water can be used to increase crop yield, induce seed germination and benefit the health of livestock. Magnetic water treatment is currently used in Australia, Bulgaria, China, England, Japan, Poland, Portugal, Russia, Turkey and the United States for these purposes, Qados and Hozyan, (2010). Up to now, different devices have been produced to magnetize water. In spite of a variety of structures and shapes for these devices, the performing mechanism is almost the same. When a fluid passes through the magnetized field, its structure and some physical characteristic such as density, salt solution capacity, and deposition ratio of solid particles will be changed (Higashitani*et al.* 1993). Othman *et al.*(2006) stated that seed germination significantly decreased by increasing salinity level. Generally, using different magnetized irrigation water sources, soil salinity, soluble cations and anions were significantly decreased by using magnetized water (Ahmed and Bassem, 2013). Aladjadjiyan and Ylieva (2003) reported that exposure the seed to a 150 mT magnetic field stimulated shoot development and led to increase of the germination, fresh weight and shoot length of maize plants. Magnetic water has found to have pronounced effect on plant productivity. Aladjadjiyan and Ylieva (2003) reported some beneficial effects of magnetically treated irrigation water particularly for saline water and recycle water, on yield and water productivity of clearly and snow pea plants under controlled environment conclusion. Yokatani et al. (2001) indicated that magnetic fields have a highly stimulating effect on cell multiplication, growth and development. Many studies reported that magnetic field had a positive effect on the number of flowers and total yield of the pea (Podlesny et al., 2005), seed germination percentage and nutrient uptake of strawberry (Fragaria x ananassa cv. Camarosa) (Esitken and Turan, 2003). Moon and Chung (2000) said that application of a magnetic field to irrigation water was shown to increase plant nutrient content. Turker et al. (2007) found an inhibitory effect of the magnetic field on root dry weight of maize plants, but there was a beneficial effect of magnetic field on root dry weight of sunflower plants. An increase in nutrient uptake by magnetic treatment was also observed in tomatoes by Duarte Diaz et al. (1997). MW can be used to increase seed germination (Ozdemir *et al.,* 2005).The application of a magnetic field has been shown to induce seed germination, and increase the percentage of germinated seeds. Moon and Chung (2000) treated tomato seeds with a magnetic field and found that germination rates were accelerated about 1.1–2.8 times when compared to the control seeds. Pinustropicalis, a tree species endemic to western Cuba, typically experiences a <50% germination rate, when seeds were treated with MW as part of a 2007 study, germination occurred in 70-81% of seeds (Morejón*et al.,* 2007). Germination of broad bean seeds was found to take place 2-3 days earlier when seeds underwent magnetic treatment (Podleoney*et al.,* 2004).But, all studies have not confirmed this increase. The appropriate strength of MF to improve biological process of WWT is not yet determined. The MF induction reported by previous studies is wide and ranges 7 to 490 MT (Yavuz and Celebi, 2000). Research carried out over the years concerning the possibility of the application of magnetically treated water in agriculture has generally been concerned with determining of its usefulness for improving seed germination and plant growth (Morejon et al., 2007). Magnetically treated water has been utilized to improve yielding conditions of desert soil in Egypt with high salinity and calcification, where higher yields were obtained for tomato, pepper, maize and wheat - (HilalandHelal, 2003). The seeds of many crops were subjected to the activity of physical stimulating factors: onion seeds were stimulated with variable magnetic fields at a frequency of 50 Hz, the greatest yield growths and greatest chive lengths were obtained at a stimulation time of 15 s. For cabbage seeds and radish stimulated with variable magnetic fields at induction of B= 30, 60,and 100 mT for stimulation times from 4 to 60 s, a positive effect on germination rate and yields was obtained for induction of 30 mT (Kornarzyñski et al., 2004).

The most important roles play genetic and environmental factors in the normal process of germination and plant growth. Akey role is also played by proper preparation before sowing, which applies to chemicals (seed dressing, growth regulators), scarification, seed stratification and physical factors: fixed and variable magnetic and electrical fields, microwave, ionizing and laser radiation), which usually positively affects germination and plant growth and the height of the yields obtained (Yi-Ping Chen et al., 2005). Barley is widely grown in the arid and semiarid regions of the Mediterranean for forage purposes and as a grain crop (alkaraki 2001). It is rated as a moderately tolerant forage crop and highly tolerant grain crop (mass and poss 1989). Barley is most sensitive to salinity at germination and young seedling stage and exhibits increased tolerance with age (storery and jones1978). They stated that salt stress for barley at seedling stage has been mainly attributed to ionic effect rather than no osmotic effect. This is different from the germination stage, where osmotic effect is the primary stress component (mano et al 1996). Salinity tolerance at germination and seedling stage determined the stand density in the field Ander saline conditions most cereals including wheat and parley are reported to be more salt-tolerant all germination at seedling stage (mass and poss 1989).

The aim of the present work is to design an electro-magnetic unit and evaluation of resulted magnetic force of different saline waters on the germination of different plant seeds laboratory and yield of turnip in a field experiment.

Material and methods

Laboratory experiments were carried out for studying the effect of electromagnetic force of saline water on seed germination of wheat (Triticumaestivum L. Gemmiza), barley (horedumvulgare L. Benisoief), sorghum (Sorghum bicolor L. Giza1), sunflower (Helianthus annuus L. Sakha 53), and turnip (Brassica rapa var. rapa L. Sakata) crops at Water Relations and Field Irrigation Dept., National Research Centre (NRC), Dokki, Giza, Egypt.

The seed germination was determined by following the ISTA (1985) method. Three replications each with 10 seeds were placed between two layers of moist germination papers, rolled carefully and wrapped in a sheet of wax paper to reduce surface evaporation. They were placed in the germination incubator at 25^{o}C in an upright position. After 12 days, germinated seeds were grouped as normal, abnormal, fresh un-germinated and dead seeds.

The germination percentage was calculated based on normal seedlings. Four seeds of ever crop divided into three equal replications, were placed in moistened filter paper in a plastic dish and were incubated at 25 ^{o}C. A daily germination count of the incubated seeds was taken until no more seeds germinated, and the speed of germination was calculated following Maguire (1962) as:

Speed of germination = $\sum (n / t)$

Where n is the number of seeds newly germinating at time t, and t is days from sow in Chosen grains were washed several times with deionized water, 10 grains were germinated on plastic pots (with drainage holes to drain excessive water and also to prevent grains from rotting) cone-shaped plastic dishes height of about 4 cm in diameter and 11 cm upper and lower 9 cm. The experiment was in laboratory of water relation and field irrigation department at National Research Centre in May 2015. Germination period lasted 13 days and was irrigate every two days during germination test, and then, later in the experiment, watered with magnetized water an average of every two days. Sproutedseeds were counted daily by counting the germs which were not removed, and which grew to the end of the study, at which time they were cut and weighed as the final mass. The total number of germinated grains was counted and calculated using the equation:

$$\text{Finalgermination\%} = \frac{\text{number of germinated grains}}{\text{total number of grains planted}} \times 100 \text{... ……..(26)}$$

Germination rate was calculated as follow:

Germination rate = (n1d1+n2d2+…+ nndn)/nt……………… (27)

Where:

n1d1= a number of germinated grains in the 1st day.

n2d2= a number of germinated grains in the 2^{nd} day.

nndn= number of germinated grains in the n day.

nt= a total number of grains used in germination .

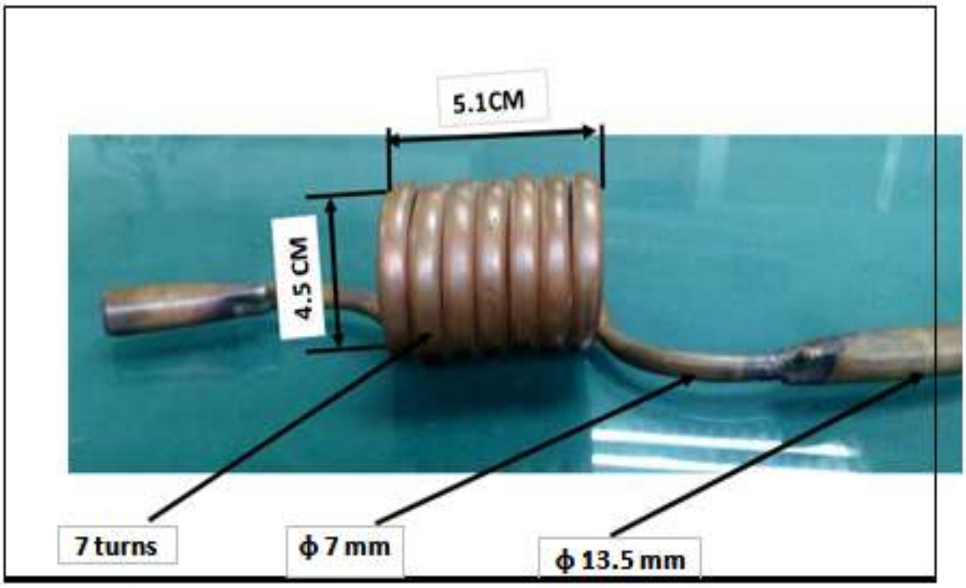

Fig.1: Solinoed of copper for treating water by magnetic force.

Salinity waters were collected from different wells to represent different salinity levels used with a final EC in the range of 345 to 4000ppm was reached germination response to salinity levels was monitored visually at 24 hr intervals for theduration of the germination test. A grain was considered to have germinated if the radical exceeded 2 lengths. Water treatments were five salinity (canal water (345), 1000, 2000 and 4000 ppm) and fourth magnetic force (0, 800, 1000 and 2000 gauss) as well as untreated one.

Water was being processed when the strength of 800 gauss by passing in solenoid manufactured of copper manually manufactured workshops conditioning as shown in Figure (1) a file component of the spiral of 7 rolls and a length of it is about 5.1 cm and pipe diameter 7 mm so as to display water magnetic field as long as possible and increase the efficiency of utilization of the field magnetic generated from the unit and raise the efficiency of the process of magnetization and shown that the distance between poles don’t less than 4.5 cm because the diameter of solinoed about 4.5 cm. All data collected were statistically analyzed as a split plot design with three replications using analysis of variance to evaluate main and interaction effects as described by Snedcor and Cochran (1982). Means among treatments were compared using Least Significant Difference (LSD) at P 0.05 probability.

Results and discussion

Figure (2) illustrated germination rate (speed) of the wheat, barley, sorghum, turnip and sunflower as affected by the interaction between water salinity (345, 1000, 2000 and 4000 ppm) treated or untreated by magnetic force (0, 800, 1000 and 2000 Gauss). Data on hand revealed that the highest values of germination rate were attained under canal water and 0 Gauss while the lower ones were recorded after 4000 ppm treated or not by magnetic force. Also, it is clear to mention that the barley seeds had a high response, whether for salinity water or magnetic treated one, while the sunflower and wheat had a weak response to salinity and moderate response for the treated magnetic one.

Regarding the magnetic force (0 to 2000 Gauss), one can notice that, treated saline water or not by magnetic force improvement germination rate where the high improvement occurred after water canal followed by increased salinity in the water. On the contrary, studying salinity effects on the germination rate of the examined plants seed had a negative effect and increased salinity associated with decreasing in germination rate as shown in Figure (3).

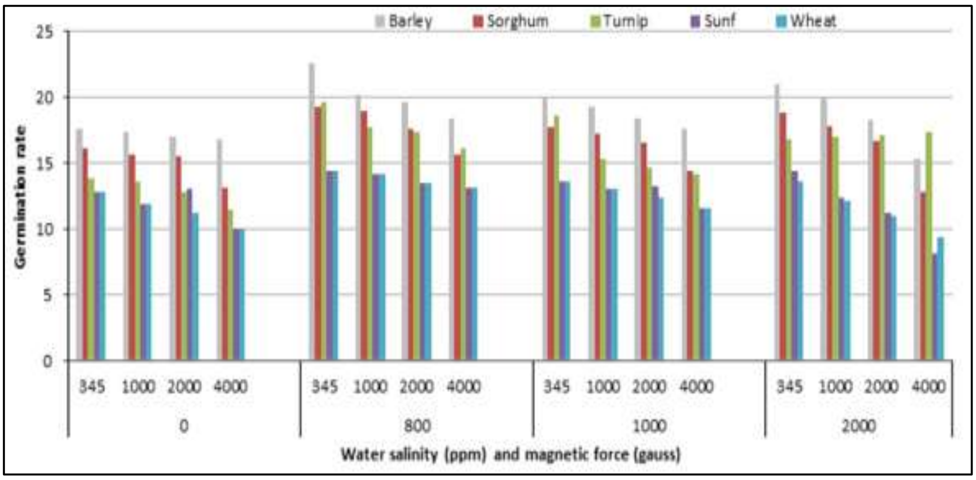

Fig.2: Effect of magnetic force and water salinity on the germination rate of barley, sorghum, turnip, sunflower, and wheat.

Fig. (18): Effect of magnetic force and water salinity on the germination rate of barley, sorghum, turnip, sunflower, and wheat.

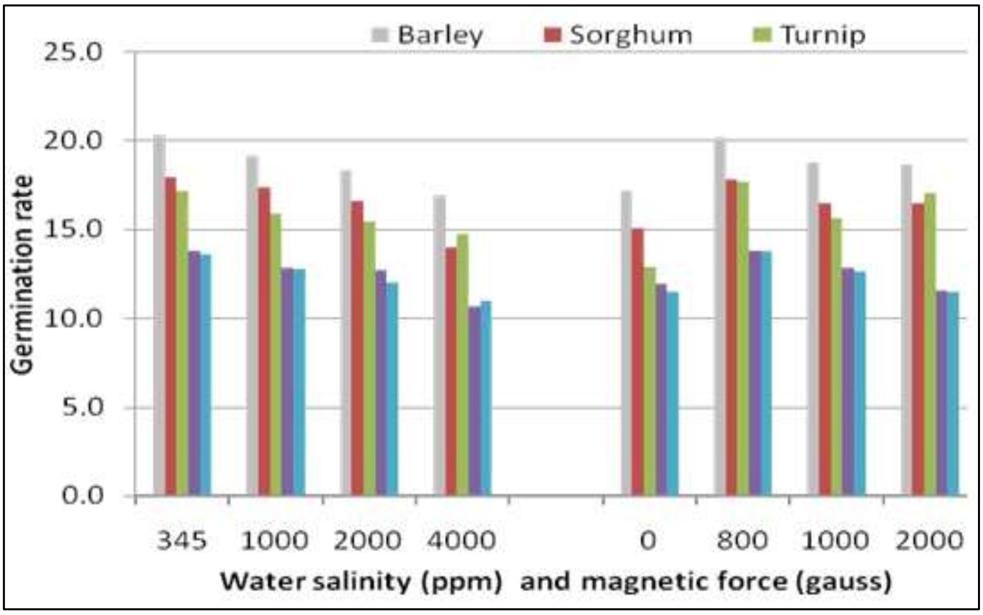

Fig. 3: Effect of magnetic force or water salinity on the germination rate of barley, sorghum, turnip, sunflower, and wheat.

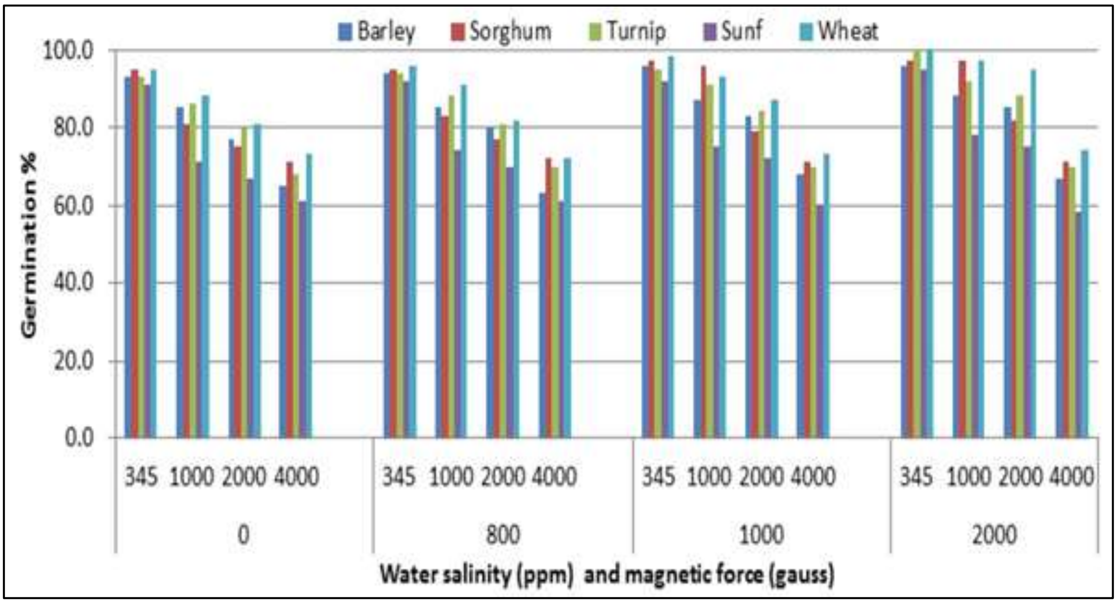

Fig. 4: Effect of magnetic force and water salinity on the germination rate of Fig. (20): Effect of magnetic force and on the germination barley, sorghum, turnip, sunflower, and wheat. percentage (%) for barley, sorghum, turnip, sunflower, and wheat.

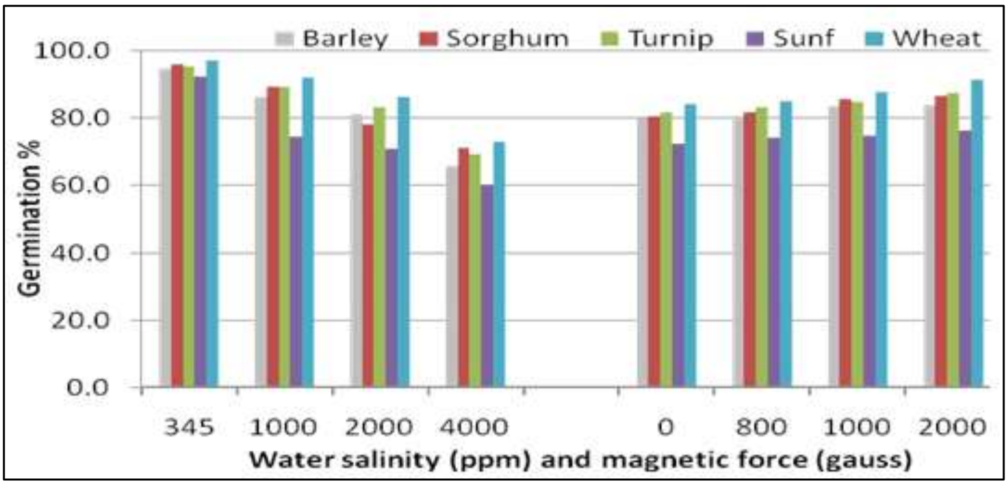

Fig. 5: Effect of magnetic force or water salinity on the germination percentage (%) for barley, sorghum, turnip, sunflower, and wheat.

This phenomenon clearly appears after salinity tolerant plant seed (barley, sorghum, and turnip). Additionally, data pointed out that magnetic force treatment (800 Gauss) slightly change would happen with increasing salinity in water, whereas, it was very clear and had the highest numbers as shown in Figure (4). Such findings coincide with those reported by Mesut *et al.* (2010), who suggested that the growing plants in saline media come across generally with major drawbacks; the first is the increase in the osmotic stress due to the high salt concentration of soil solution that decreases water potential of soil; the second is the increase in concentration of Na and Cl.

With respect to the germination percentage of the wheat, barley, sorghum, turnip and sunflower as affected by the interaction between water salinity treated or not by magnetic force (0, 800, 1000 and 2000 Gauss), data in Figures (3; 4) showed that water salinity had a negative effect on germination % of sunflower seeds was the most affected one followed by wheat seeds.

Barley germination rate under no magnetic was not clear to decrease with increasing salinity, which means that it is a more tolerant plant to salinity. Although barley is most sensitive to salinity at germination and young seedling stage and exhibits increased tolerance with age (Storery and Jones, 1978), who found that salt stress for barley at seedling stage has been mainly attributed to ionic effect rather than no osmotic effect.

This is different from the germination stage, where the osmotic effect is the primary stress component (Mano *et al.*, 1996). Salinity tolerance at germination and seedling stage determined the stand density in the field under saline conditions most cereals including wheat and parley are reported to be more salt-tolerant all germination at seedling stage (Mass and Poss, 1989).

Additionally, magnetic force is enhancement germination percentage for all examined seed. Also, results indicated that any increasing magnetic force faced by improving germination % under all investigated seeds, especially wheat and sunflower followed by sorghum.

It is worthy to mention that magnetic force 2000 Gauss had a positive effect on germination percentage (%) than 1000 Gauss with significant differences as shown in Figures (4; 5) (in appendix). The rates of increase in the germination percentage (%)

were 4,7,4,3; 4 and 5,8,7,6;9 for wheat, barley, sorghum, turnip and sunflower as affected at magnetic force 1000 and 2000 Gauss, respectively. Also, it is clear to point out that there are no significant differences between germination percentage (%) at 0 and 800 Gauss for all germinated seeds.

Generally, magnetic force is enhancement germination percentage (%) for all examined seeds. Where, results indicated that any increasing magnetic force faced with improving germination % under all investigated seeds, especially wheat and sunflower followed by sorghum. Our data supported by those obtained by Amaya *et al.* (1996) and Podleoeny*et al.* (2004) who reported that seed germination percentage and speed of emergence was improved after irrigation water treated by a magnetic field. Additionally, the reason of this effect can be searched in the presence of paramagnetic properties in a chloroplast which can cause an acceleration of seed metabolism by magnetic treatment (Aladjadjiyan and Ylieve, 2003).

Conclusions

Data revealed that the highest values of germination rate were attained under canal water while the lowest ones were recorded after 4000 ppmtreated or not by magnetic force. Barley seeds had a highly response whether for salinity water or treated magnetic one, while the sunflower and wheat had a weak response to salinity and moderately response for the treated magnetic one.

Both germination percentage and rate were improved after irrigation water treated by a magnetic field. Germination percentage and rate were examined in a laboratory experiment to study the impact of water salinity (345, 2000, 4000 ppm) and/or magnetic force (0, 800, 1000 and 2000 Gauss) of different plants (wheat, barley, sorghum, turnip, and sunflower).

References

1. Ahmed .M, I. and Bassem. M.E. (2013). Effect of irrigation with magnetically treated water on faba bean growth and composition. International Journal of Agricultural Policy and Research. 1(2): 24-40.
2. Aladjadjiyan, A. and T. Ylieva (2003). Influence of stationary magnetic field on early stages of the development of tobacco seeds (Nicotina tabacum). J. Cent. Eur. Agric., 4: 132–138.
3. AL-Karaki, G. N. (2001). Germination, sodium and potassium concentration of barley seeds as influenced by salinity. J. plant Nutr., 24: 511–522.

4. Amaya, J. M.; M. V. Carbonell; E. Martinez and A. Raya (1996). Effects of stationary magnetic fields on germination and growth of seeds. Hort. Abst., 68, 1363pp.
5. Ambashta, R. D. and M. Sillanpää (2010). Purification using magnetic assistance: a review.Journal of Hazardous Materials, 180: 38–49.
6. Bernstein, L., (1975). Effect of salinity and sodality on plant growth. Ann. Rev.Phytopathol. 13: 295-312.
7. Demir, I.; K. Mavi; M. Zcoban and G. Okcu (2003). Effect of salt stress on germination and seedling growth in serially harvested aubergine (Solanum melongena L.) seeds during development. Israel J. Plant Sci., 51: 125–131.
8. Duarte Diaz, C. E.; J. A. Riquenes; B. Sotolongo; M. A. Portuondo; E. O. Quintana and R. Perez (1997). Effects of magnetic treatment of irrigation water on the tomato crop. Horticultural Abstracts, 69, 494pp.
9. Esitken, A. and M. Turan (2003). Alternating magnetic field effects on yield and plant nutrient element composition of strawberry (Fragaria x ananassa cv. Camarosa). Acta Agriculturae Scandinavica. Section B, Soil and Plant Sci., 5: 135–139.
10. Ghoulam, C. and K. Fares (2001). Effect of salinity on seed germination and early seedling growth of sugar beat (Beta vulgaris L.). Seed Sci. Technol., 29: 357–364.
11. Hampson, C. R. and G. M. Simpson (1990). Effects of temperature, salt and osmotic pressure on early growth of wheat (Triticum aestivum L.). Can. J. Bot., 68: 524–528.
12. Higashitani, K.; A. Kage; S. Katamura; K. Imai and S. Hatade (1993). Effects of a magnetic field on the formation of CaCO3 particles. Colloid and Interface Science, 156(1): 90– 95.
13. Hilal, M. H. and M. M. Helal (2003). Application of magnetic technologies in desert agriculture: Seed germination and seedling emergence of some crops in a saline calcareous soil. Proc. II Int. Conf. Impact of electromagnetic fields in the agricultural environment, Agrolaser, Lublin, Poland.
14. ISTA (1985). International rules for seed testing. Seed Sci. Technol.
15. Khajeh-Hosseini, M.; A. A. Powell and I. J. Bingham (2003). The interaction between salinity stress and seed vigor during germination of soybean seeds. Seed Sci. and Technol., 31: 715–725.
16. Kney, A. D. and S. A. Parsons (2006). A spectrophotometer-based study of magnetic water treatment: Assessment of ionic vs. surface mechanisms. Water Research, 40(3): 517– 524.
17. Kornarzyñski K., Pietruszewski S., and Segit Z., 2004. Preliminary studies of variable magnetic field on the growth rate of wheat germ (in Polish). Acta Agrophysica, 112, 521-528.
18. Maas, E. V. and S. R. Grattan (1999). Crop yields as affected by salinity. In: Pessarakli, M. (ed.): Handbook of Plant and Crop Stress. Marcel Dekker, New York: 55–108.
19. Maheshwari, B. L. and H. S. Grewal (2009). Magnetic treatment of irrigation water: Its effects on vegetable crop yield and water productivity. Agric. Water Manag. 96(8): 1229-1236.
20. Mano, Y.; H. Nakazumi and K. Takedia (1996). Varietal variation in and effects of some major genes on salt tolerance at the germination stage in barley. Breeding sci., 46: 227-233.
21. Mass, E. V. and J. A. Poss (1989). Salt sensitivity of cowpea at various growth stages. Irr. Sci., 10: 313–320.
22. Mehmet, A.; M. D. Kaya and G. Kaya (2006). Effects of NaCl on the germination, seedling growth and water uptake of triticale, Turk J. Agric., 30: 39-47.
23. Mesut, C. K.; T. Onder; T. Metin and T. Burcu (2010). Phosphorus and humic acid application alleviate salinity stress of pepper seedling. African Journal of Biotechnology, 9: 5845–5851.
24. Moon, J. D. and H. S. Chung (2000). Acceleration of germination of tomato seed by applying AC electric and magnetic fields. J. Electrostatics, 48: 103–114.
25. Morejon, L. P.; J. C. Castro Palacio; L. Velazquez Abad and A. P. Govea (2007). Simulation of Pinus Tropicalism: seeds by magnetically treated water. Int. Agrophysics, 21: 173– 177.
26. Neumann, P.M., (1995). Inhabitation of root growth by salinity stress: Toxicity or an adaptive biophysical response. In: Structure and Function of Roots. Baluska, F., M. Ciamporova, O. Gasparikova and Barlow, P.W. (Eds.), the Netherlands: Kluwer Academic Publishers, pp: 299-304.
27. Othman, Y.; G. Al-Karaki; A. R. Al-Tawaha and A. Al-Horani (2006). Variation in germination and ion uptake in barley genotypes under salinity conditions. World Journal of Agricultural Sciences, 2(1): 1–15.
28. Ozdemir, S.; O. H. Dede and G. Koseoglu (2005). Electromagnetic water treatment and water quality effect on germination, rooting and plant growth on flower. Asian Journal of Water, Environment and Pollution, 2(2): 9–13.
29. Passioura, J.B., (1988). Root signals control leaf expansion in wheat seedlings growing in drying soil, Aust. J. Plant Physiol., 15: 687–693.
30. Podleoeny, J.; S. Pietruszewski and A. Podleoena (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. Int. Agrophys, 18: 65–71.
31. Podlesny, J.; S. Pietruszewski and A. Podlesna (2005). Influence of magnetic stimulation of seeds on the formation of morphological feature sand yielding of the pea. Int. Agrophys., 19:1–8.
32. Qados, A. and M. Hozayn (2010). Magnetic water technology: A novel tool to increase growth, yield, and chemical constituents of lentil (lens esculenta) under greenhouse condition. American-Eurazian J. Agric. and Environ. Sci., 7(4): 457–462.
33. Saboora, A. and K. Kiarostami (2006). Salinity tolerance of wheat genotype at germination and early seedling growth. Pakistan Journal of biological Sciences, 9(11): 2009–2021.
34. Snedcor, G. W. and W. G. Cochran (1988). Statistical methods. 7th Edition, The Iowa State University Press, Iowa, 507pp.
35. Storey, R. and R. G. Jones (1978). Salt stress and comparative physiology in the graminae: I. Ion relations of two salt-and water-stressed barley cultivars. California Mariout and Arimar. Aust. J. Plant physoil., 5: 801–816.
36. Turker, M.; C. Temirci; P. Battal; M. E. Erez (2007). The effects of an artificial and static magnetic field on plant growth, chlorophyll and phytohormone levels in maize and sunflower plants. Phyton Ann. Rev. Bot., 46: 271–284.

37. Willenborg, C. J.; R. H. Gulden; E. N. Johnson and S. J. Shirtliffe (2004). Germination characteristics of polymer-coated canola (Brassica Napus L.) seeds subjected to moisture stress at different temperatures. Agron. J., 96: 786–791.
38. Yavuz, H. and Celebi, S.S. (2000). Effects of magnetic field on activity of activated sludge in wastewater treatment. Enzyme and Microbial Technology, 2000. 26(1): p. 22-27.
39. Yokatani KT, Hashimoto H, Yanagisawa M, Nakamura T, Hasegawa K, Yamashita M (2001). Growth of Avena seedlings under a low magnetic field. Biol. Sci. in Space 15: 258-259.
40. Yi-Ping Chen, Ming Yuea, and Xun-Ling Wanga, 2005. Influence of He-Ne laser irradiation on seeds thermodynamic parameters and seedlings growth of Isatis indogotica. Plant Sci., 168, 601-606.
41. Yurttas, B.; C. Atak; G. Gokdoan; Y. Canbolat; V. Danilov and A. Rzakoulieva (1999). Detection of the positive effect of magnetic field on sunflower plants (Helianthus annuus L.). Turkish Association of Biophysics, XI, National Biophysics Congress, Abstract Book, 59: 11–94.