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Effect of magnetized seeds and magnetized saline water on seed germination and seedling growth of tall wheatgrass (*Agropyron elongatum*)

Abbas Bagheri[1*], Mohammad Jafari[2], Mohsen Movahedi Dehnavi[3], Sayed Akbar Javadi[4], Ali Ashraf Jafari[5]

[1]*Faculty of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, P.O. Box 14515-775, Tehran, Iran*
[2]*Faculty of Natural Resources, Tehran University, Tehran, Iran*
[3]*Faculty of Agriculture, Yasouj University, Yasouj, Iran*
[4]*Faculty of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, P.O. Box 14515-775, Tehran, Iran*
[5]*Research Institute of Forests and Rangelands, PO. BOX 13185-116, Tehran, Iran*

Key words: Tall Wheatgrass (*Agropyron elongatum*), Germination, Magnetize water, Salinity and Magnetic seed treatments.

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Abstract

This study has been performed to investigate the effect of magnetization of normal and saline water, and magnetized seed on seed germination properties (germination percent, speed of germination, seed vigor, root length, shoot length, seedling length, shoot weight, root weight and seedling weight) of tall wheatgrass *Agropyron elongatum* in the laboratory condition in Yasouj University, Iran, in 2012. A three factor experiment was conducted based on completely randomized design with four replications. The factors were: salinity in three levels (control, 100 and 200 mM sodium chloride and calcium chloride with proportion 1:1), magnetized water in five intensity levels (0, 2.5, 5, 7.5 and 10 KG), and magnetized seeds in five levels (0, 2.5, 5, 7.5 and 10 KG). The result of analyses of variance showed significant interaction effect between salinity and magnetic water and salinity and magnetic seed for all of traits except germination percent. Interaction effects of magnetic water and magnetic seed was significant for only root length. Results showed that by increasing salinity all of seed germination traits were reduced regardless of water and seeds treatments. In non saline water the maximum values were obtained by magnetic water treatment of 2.5 and 5 KG and magnetic seeds of 7.5 and 10 KG. In saline water of 100 mM, the higher values of seed properties were obtained in magnetic water intensity of 2.5 KG and magnetic seeds intensity of 7.5 KG. In sever salinity 200 mM, both magnetic water and magnetic seed had no effect on seed germination traits. It was concluded that magnetization was more effective on non saline water than that for saline water in seedling growth of *A. elongatum*. For magnetic water lower strengths in range of 2.5 and 5 KG and for magnetic seed the higher strengths in range of 7.5 and 10 KG are suggested. In overall for simplicity and lower cost using the magnetic water are preferred than magnetized seeds.

* **Corresponding Author:** Abbas Bagheri ✉ bagheriyasoj@yahoo.com

Introduction

Tall wheatgrass (*Agropyron elongatum* Host.) is an important cool-season grass that is used for ranges improvement in Iran. It is well adapted to steppe or semi steppe region of Iran. It is used for pasture, hay, and erosion control. It is native to the Eastern Mediterranean Region (Darbyshire, 1997). Tall wheatgrass can survive under dryland conditions and alkaline soils with a pH between 7.5-9 (Roundy, 1985; Undersander and Naylor, 1987). Tall wheatgrass could persist in soils with conductivity up to electrical conductivity (EC) of 26 mmhos/cm (Ogle *et al.,* 2008).

Environmental stresses such as salinity stress greatly influence the growth and productivity of forage grasses also it is considered as one of the most important determinants of crop cultivation and agricultural diversity especially in arid and semi arid regions. Salinity inhibits the seed germination lengthens the time needed for germination, it also discourages the overall growth of plants and reduces the final crop yield (Hernandez *et al*., 1995).

Magnetic seed treatment is one of the physical pre-sowing seed treatments as well as magnetically water treatment. The influence of magnetic field on various growth processes of plants such as seed germination, seedling growth, plant growth, yield and the properties of crop quality have been the aims of much research.

Jones *et al.,* (1986) found that the electromagnetic fields amplify the plant growth regulator induced Phenylalanine Ammonia-Lyrase during cell differentiation in the suspended cultured plant cell. Reina *et al.,* (2001) studied water absorption by lettuce seeds previously treated in a stationary magnetic field of 010- mT. They found significance increase in the rate of water absorption accompanied with an increase in the total mass. They interpret the results by the variations induced by magnetic fields in the ionic currents across the cellular membrane with leads to change in the osmotic pressure. They concluded that magnetic field alters the water relations in seeds and for that germination rates change by the magnetic field.

According to the data obtained from Russia, Australia, Poland, Turkey, Portugal, England, United States, China and Japan (Yakovlev *et al*., 1990 and Cakmak *et al*., 2010) decrease of soil alkalinity, increase in mobile forms of fertilizers, increase in crop yields, and earlier vegetation periods can be achieved by magnetized water treatment. Moreover, Celik *et al.,* (2008) reported that magnetic field is known as an environmental factor which effects on gene expression. Therefore, by augmentation of biological reactions like protein synthesis Chickpea yield and its components were increased significantly under magnetic irrigation.

Fischer *et al.,* (2004) reported that sunflower seedlings exposed to 16 Hz Sinusoidal 20 mT (rms) vertical magnetic fields showed small but significant increases in total fresh weight, shoot fresh weight and root fresh weight, while the dry weight and germination rates remained unaffected. Vashisth and Nagarajan, (2008) reported on increase in speed of germination, seedling length and seedling dry weight for *Cicer arietinum* L. with static magnetic field of 50 mT for 1-4 h. They also reported positive results in the growth of maize, chickpea and sunflower seeds exposed to static magnetic field (Vashisth and Nagarajan, 2010).

Samir Nasher, (2008) found that chick pea plants irrigated with magnetized water were taller than plants irrigated with tap water Significant increases in pigment fractions were recorded in chickpea plants irrigated with magnetized water compared to control treatment. Reina *et al.,* (2001) found significance increase in the rate of water absorption accompanied with an increase in total mass of lettuce with the increase of magnetic force. Aladjadiyan, (2002) found that corn seed exposed to a 150 mT magnetic field stimulated the shoot development and led an increase in the maize germination. Racuciu and *et al.,* (2008) reported that the activities of some enzymes were increased by exposure to magnetic field.

The magnetic field worth attention, since it can change the course of some processes taking place in the seeds and so stimulates plant development, particularly under stress conditions. It had been widely used in some countries, since the magnetic field treatment is ecological and harmless technology (Carbonell *et al.*, 2004).

The more previous studies done on this topic were performed on Agronomy and Horticulture species while rangeland species was not considered yet. Since Iran has located in arid zone and has the more rangeland, techniques and new methods are needs for development of this rangeland that save in water consumption in this zone.

The aim of our study was quantify the effect of magnetic seeds and magnetic water treatments, on seed germination particularly under saline conditions on *A. elongatum* seedling growth.

Materials and methods

Experimental design

This experiment was done at faculty of agriculture at Yasouj University, Iran. The normal ISTA, (1985) laboratory germination test procedure was used with five treatments of magnetic water intensity (0, 2.5, 5, 7.5, 10 KGauss) and 3 salt stress level (0, 100, 200 mM) of sodium chloride and calcium chloride that mixed in 1: 1 ratio. To produce magnetic seeds, the seeds were exposed to magnetic field strengths for 6 h. The saline water also exposed to magnetic field strengths using plastic tube containing of water that placed upside of tube.

Seeds were sterilized with 5% sodium hypochlorite and washed with distilled water. Four replicates (25 seeds per replicate) of sterilized seed were placed in Petri dishes on double Whatman papers (TP). The samples were immediately transferred into a germinator at (20±4°C) for 20 days. The Petri dishes were irrigated firstly by saline water and then irrigated just by normal magnetic water. To prevent of fungi pollution the benomil fungicide was used.

Data collection and analysis

The percent and speed of germination were recorded at 3, 6, 9, 12 and 15 days. In accordance with Maguire, (1962) the speed of germination was calculated by the following equation:

$$G.S = \frac{\sum n}{\sum n(n \times DN)} \times 100$$

Where:

n=is the number of seed germinated on days,

DN=number of days after sowing corresponding to n, and the highest

G.S. = Germination speed.

At the end of germination period, the length of roots and shoots of 10 randomly-selected seedlings from each replicate were measured. After measuring shoot and root lengths, the 10 fresh seedlings were placed in Owen 70°C for 24 h and then the dry weight of stem and root was measured. The vigour index measures seedling performance, relating together the germination percentage and growth of seedlings produced after a given time (Abdul-Baki and Anderson, 1973). It is calculated by following equation:

$$Vi = \frac{\%Gr \times MSH}{100}$$

Where:

VI = vigour index

%Gr = final germination percentage

MSH = mean seedling height.

The data were analyzed as a factorial experiment using the SAS software and mean comparison was done by Duncan's multiple range tests.

Results and discussion

Analysis of variance

The result of analyses of variance showed significant effect of salinity and magnetic water for all of traits except germination percent. The effect of magnetic seed was also significant for all of traits except root length. The result indicated the significant interaction effect between salinity and magnetic water and

salinity and magnetic seed for all of traits except germination percent. The interaction between magnetic water and magnetic seed was significant only for root length (Table 1).

Table 1. Summary of analysis of variance and the level of significant mean squares.

Source of variation	DF	Germination percent	Germination speed	Root length (mm)	Stem length (mm)	Seedling length (mm)	Stem Weight (mg)	Root weight (mg)	Seedling weight (mg)	Seed Vigor
Salinity (S)	2	**	**	**	**	**	**	**	**	**
Magneticwater (MW)	4	ns	**	**	**	**	**	**	**	**
Magnetic seed (MS)	4	*	**	ns	**	**	*	*	*	**
S x MW	8	ns	**	*	**	**	**	**	**	**
S x MS	8	ns	*	**	**	**	**	**	**	**
MW x MS	16	ns	ns	ns	**	ns	ns	ns	ns	ns
S x MW x MS	31	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns, *and ** = non significant, significant at the 0.05 and 0.01 probability level, respectively.

Effect of salinity and magnetic water on germination traits

The effect magnetic treatment of both saline and non saline water was compared for seed germination traits of *A. elongatum* (Table 2). By increasing salinity, the germination percentage, was reduced. The higher germination percentage was obtained in non saline magnetic water of 7.5 KG. However, the magnetic saline water of 100 and 200 mM, had no significant effect on germination percentage. For germination speed results showed that by increasing salinity, the germination speed was reduced. In both saline and non water, the magnetic water treatments had no significant effects on germination speed (Table 2).

Table 2. Effect of salinity and magnetic water on germination *A. elongatum*.

Salinity (mM)	Magnetic water (KGauss)	Germination percent	Germination speed	Root length mm)	Stem length (mm)	Seedling length (mm)	Stem weight(mg)	Root weight (mg)	Seedling weight (mg)	Seed Vigor
0	0	97.0 b	6.00 a	86.79 a	117.25ab	204.04 bc	21.38 b	10.85 b	32.23 b	198.0bc
0	2.5	96.0 c	5.84 a	89.14 a	121.40 a	210.60 ab	20.79 c	11.17 b	31.96 b	202.0ab
0	5	97.2 b	5.96 a	92.08 a	122.15 a	215.85 a	22.72 a	13.07 a	35.60 a	209.85a
0	7.5	100 a	5.95 a	77.80 b	113.25 b	191.17 d	20.97 bc	11.12 b	31.91 b	191.1cb
0	10	97.0 b	5.98 a	79.60 b	114.46 b	194.05 cd	19.06 ef	10.05 bc	29.20 c	188.1 c
100	0	96.2 bc	4.65 b	59.81cd	93.70 c	153.51 ef	20.32 d	8.06 e	28.38 d	148.5 d
100	2.5	95.0 cd	4.79 b	61.28 c	95.57 c	156.85 e	21.99 ab	9.08 dc	31.07 bc	149.0 d
100	5	93.0 de	4.07 d	56.98cd	87.51 de	144.48 f	19.79 de	8.61 e	28.39 d	134.7 f
100	7.5	94.2 cd	4.56 bc	52.83 d	80.44 f	133.27 h	17.59 g	7.21 f	24.70 f	125.6 g
100	10	92.8 e	4.31 dc	57.13cd	83.22 ef	140.35 gh	18.98 ef	7.10 f	26.08 e	130.1 fg
200	0	93.4 d	4.69 b	60.89 c	94.09 c	154.98 ef	19.73 de	7.20 f	26.93 e	143.9de
200	2.5	94.2 cd	4.31 dc	60.10cd	89.76 cd	149.94 f	18.75 f	6.15 g	24.90 f	141.2 e
200	5	94.0 cd	4.16 d	55.12cd	80.90 f	136.11 h	18.57 fg	8.01 ef	26.58 e	128.6 g
200	7.5	95.4 cd	4.65 b	56.03 cd	80.75 f	136.77 h	18.6f g	6.76 fg	25.36 e	130.3 fg
200	10	93.0 6d	4.20 d	56.27 cd	79.82 f	136.09 h	19.13 ef	7.31efg	26.44 e	127.4 g

Means with the same letter in each column represent non-significant at 5% probability level.

For root, stem and seedling length, the trends were the same and by increasing salinity, their values were reduced. The higher values were obtained in non saline water. However, the magnetic non saline water of 5 KGauss, had significantly increased seedling length by 10% higher than control (Table 2).

The results of root, stem and seedling weight were similar and by increasing salinity, their values were reduced. The effect of magnetic non saline water and magnetic saline water of 100 mM were significant. In non saline water, the magnetic intensity of 5 KGauss

had significantly increased root, stem and seedling weight by 7%, 20% and 11%, respectively than that for control. Similarly, the magnetic saline water of 100 mM and intensity of 2.5 KGauss had significantly increased root, stem and seedling weight by 8%, 12% and 10%, respectively than that for control (Table 2).

The results of vigor index showed that by increasing salinity, its values were reduced. The higher values were obtained in non saline water. The magnetic non saline water of 5 KGauss, had significantly increased vigor index by (6%) higher than control (Table 2 and Fig 1a).

In agreement with our results, there are many reported that improved percent of germination rate in different plants when exposed to magnetic intensity because of improved of water uptake and biochemical changes of seed mixture and changes of enzymes involved in germination (Cakmak *et al*., 2010). They found acceleration of germination and early growth of wheat and bean seedlings grown under various magnetic field and osmotic conditions. Similar to our results Aladjadjiyan, (2002) found increase of energy of germination by the magnetic field 15mT.

Effect of salinity and magnetic seeds on germination traits

The effect magnetic seed on seed germination traits of *A. elongatum* is presented in Table 3. Both seed germination percent and speed of germination values were reduced by increasing salinity levels. For all non saline and saline water, there were no significant effects of magnetic seed on germination percent and speed of germination (Table 3). The effect of salinity on root, stem and seedling length was the same and they were reduced by increasing salinity. The magnetic seeds of 10 and 7.5 KGauss in non saline water had led to increasing of 15% and 6%, root and seedling length, respectively than that for control. For 100 mM saline water, the magnetic seeds of 7.5 KGauss increased (3%) seedling length higher than that for control (Table 3).

Table 3. Comparison of average effects of magnetic seed and salinity interactions on seed germination of *A. elongatum*.

Salinity (mM)	Magnetic Seed (KGauss)	Germination percent	Germination speed	Root length mm)	Stem length (mm)	Seedling length (mm)	Stem weight(mg)	Root weight (mg)	Seedling weight (mg)	Seed Vigor
0	0	97.0 ab	6.17 a	79.90 b	122.90 a	203.46 b	20.63 b	9.60 c	30.22 c	197.24 b
0	2.5	97.2 ab	5.90 ab	82.77 b	112.95 cd	195.72 bc	19.38 de	10.34 bc	29.72 cd	190.29 c
0	5	97.6 ab	5.69 b	81.28 b	110. 00 d	191.28 c	20.31 bc	10.69 bc	30.82 bc	186.65 c
0	7.5	98.0 a	6.11 a	89.58 a	124.84 a	215.06 a	21.91 ab	11.80 b	33.71 ab	210.63 a
0	10	97.4 ab	5.87 ab	91.88 a	117.82 bc	210.19 a	22.68 a	13.83 a	36.49 a	204.42ab
100	0	95.8 bc	4.49 cd	56.33 c	91.49 e	147.82 e	19.63 de	7.89 ef	27.52 de	141.61 d
100	2.5	94.2 d	4.56 cd	59.16 c	87.80 f	146.96 e	18.71 de	7.26 f	25.97 f	139.11de
100	5	95.0 bc	4.68 c	55.37 c	82.68 fg	138.05 ef	19.17 de	7.99 ef	26.99 ef	131.45 e
100	7.5	93.6 bc	4.53 cd	60.14 c	91.65 e	151.79 d	20.81 ab	8.57 de	29.38 d	142.07 d
100	10	92.8 de	4.14 e	54.81 c	81.14 g	135.94 f	19.93 d	8.23 ef	28.16 de	125.02 f
200	0	95.4 bc	4.41 d	61.43 c	84.31 fg	145.74 e	20.37 cd	8.53 de	28.90 de	138.74de
200	2.5	93.4 de	4.43 d	61.12 c	88.66 ef	149.78 de	19.26 de	6.86 fg	26.12 f	139.93de
200	5	94.8 c	4.39 d	55.82 c	82.51 fg	138.33 ef	18.39 ef	7.07 f	25.46 fg	131.17 e
200	7.5	95.8 bc	4.48 cd	54.96 c	82.48 fg	137.44 ef	17.92 f	6.68 fg	24.60 g	131.53 e
200	10	91.8 e	4.31 de	53.96 c	85.13 fg	139.08 ef	18.48 e	6.17 g	24.65 g	127.66 ef

Means with the same letter in each column represent non-significant at 5% probability level.

The results of root, stem and seedling weight were similar and by increasing salinity, their values were reduced. The effect of magnetic seed in non saline water was significant. Magnetic seeds of 10 KGauss had significantly increased root, stem and seedling weight by 10%, 42% and 21%, respectively than that for non magnetic seed. Similarly, in 100 mM saline water the magnetic seed of 7.5 KGauss had significantly increased root weight by 6% than that for control (Table 3).

The results of vigor index showed that by increasing salinity, its values were reduced. The higher values were obtained in non saline water. The magnetic seed of 7.5 KGauss in non saline water had significantly increased vigor index by (7%) higher than control (Table 3 and Fig 1b).

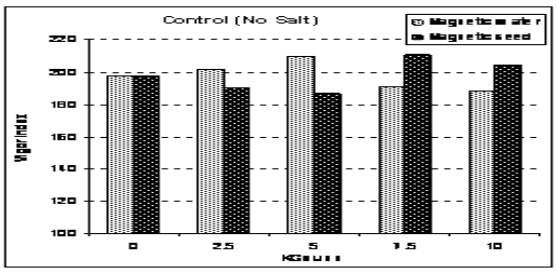

Fig. 1a.

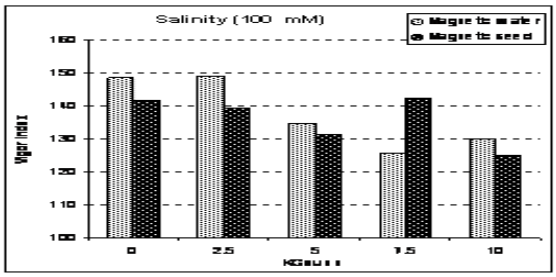

Fig. 1b.

In agreement with our results Sakhnini, (2007) found increasing in germination of bean seeds under magnetic induced may influenced Chloride Calcium different concentrations. Treatments of seeds by 500 or 2500 Gaus in period of 1-4 h led to increase of germination rate in 5 to 9%. Vashisth and Nagarajan, (2010) proposed that under magnetic intensity activity of hydrolytic enzymes led to increase of germination rate. Similar to our study, some published data indicated that magnetic field has no significant effect germination in saline environment. The negative effects of salinity may duo to direct effects of salt on cell division rate or decrease in development period (Hernandez *et al.*, 1995; Takemura *et al.*, 2000).

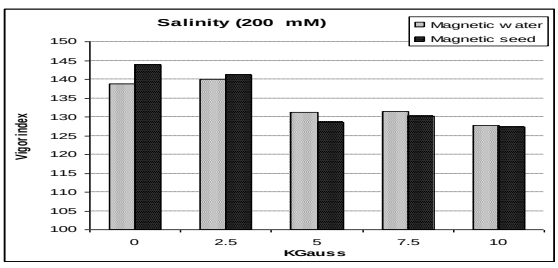

Fig. 1c.

Fig 1. Effects of magnetic water and magnetic seeds on vigor index of *A. elongatum* in three salinity levels

Conclusions

Results showed that by increasing salinity all of seed germination traits were reduced regardless of magnetic water and magnetic seeds. In non saline water the maximum values were obtained by magnetic water treatment of 2.5 and 5 KG and magnetic seeds of 7.5 and 10 KG. The higher seed vigor was obtained in saline water 100 mM and magnetic intensity of 2.5 KG and magnetic seeds of 7.5 KG. In sever salinity 200 mM, the magnetic water and magnetic seed had no effect on seed germination treats. It was concluded that magnetization was more effective on non saline water than that for saline water in seedling growth of *A. elongatum*. For magnetic water lower magnetic strengths in range of 2.5 and 5 KG and for magnetic seed the higher magnetic strengths in range of 7.5 and 10 KG were suggested. In overall for simplicity and low cost the production of magnetic water are preferred than magnetized seeds.

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