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Consequences of Magnetized Water Application on Maize Seed Emergence in Sand Culture

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ABSTRACT

Present study examines whether there is any beneficial effect of magnetized water application on seedling emergence of maize seeds. Water from various sources like tap water, saline water (1,500 ppm), canal water, and sewerage water was treated magnetically by passing it through 235 mT magnetic fields at 3 lpm flow rate. Seeds were soaked in water for 24 hours and planted in sand culture. Number of seedling emerged were counted on daily basis while growth data was measured 15 days after planting. Emergence indicators like Emergence Index (EI), Emergence Rate Index (ERI) and Mean Emergence Time (MET) were used to evaluate the germination of maize seed. Results of the present study revealed that application of magnetized water promoted the germination of maize seeds. Emergence index and emergence rate index values increased from 5.50 to 8.92 and 10.06 to 12.84 and the mean emergence time was reduced 17.90% for magnetized sewerage water in contrast to non-magnetized. Magnetized water treatment showed faster and heavier growth in all water types. Overall, the maximum increase in length and weight of emerged seedlings was noted with magnetized sewerage water. Since the results are based on limited laboratory scale study, further testing of magnetized water application in irrigated environment is suggested before making any concrete recommendations.

Keyword: Magnetic Treatment, Maize Seed Germination, Sand Culture, Water Quality.

INTRODUCTION

Agricultural sciences take an interest not only in the common and valued crop-farming factors, but also in those less expensive and generally underestimated such as ionizing, laser or ultra violet radiation and electric and magnetic field. The magnetic technology has been investigated since the turn of the 19th century. The water treated by the magnetic field or passed through a magnetic device has been called magnetized water. This magnetized water has successful use in irrigation, industry, and home use. Plants became more and more an attractive model system for studying the biological effects of magnetic fields (Racuciu and Creanga, 2005). Researchers have reported that 125 and 250 mT magnetic treatment produced a biostimulation on the initial growth stages and increased the germination rate of several seeds such as rice (Carbonell *et al.,* 2000; Flórez *et al.*, 2004), wheat (Martínez *et al.*, 2002), and barley (Martínez *et al.*, 2000). Yinan *et al.* (2005) published that the magnetic field pretreatment had a positive effect on cucumber seedlings, such as stimulating seedling growth and development. Tai *et al.* (2008) observed that subjecting water to magnetic field leads to modification of its properties, as it becomes more energetic and able to flow, which can be considered as a birth of new science

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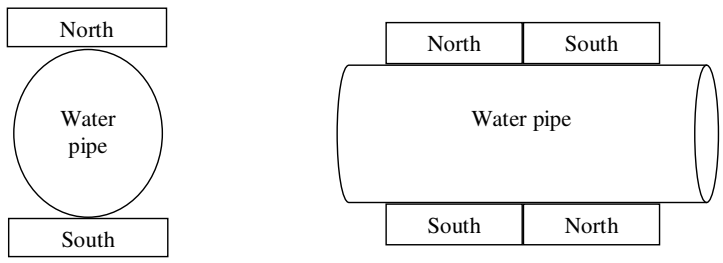
called magneto biology. He also pointed out that magnetized water prevents harmful metals such as lead and nickel from uptake by roots and reaching fruits and roots. However, it increases the percentage of nutrient elements like phosphorus, potassium and zinc in plants. Grewal and Maheshwari (2011) investigated the effects of magnetic treatment of irrigation water on snow pea and Kabuli chickpea seeds emergence, early growth and nutrient contents under glasshouse conditions. Hozayn and Qados (2010) investigate the application of magnetic water for wheat crop production and found improvements in quantity and quality of wheat. Therefore, using magnetic water treatment could be a promising technique for agricultural improvements, but extensive research is required on different crops. Maheshwari and Grewal (2009) conducted a study to examine whether there were any favorable effects of magnetic water treatment on water productivity and yield of snow pea, celery, and pea plants. Generally, the results pointed out beneficial effect of magnetic treatment, particularly for saline water and recycled water, on the yield and water productivity of celery and snow pea plants under controlled environmental conditions. The aim of the present study was to evaluate the effect of various types of magnetized water on the germination and emergence of maize seeds under laboratory condition.

MATERIALS AND METHODS

Germination tests were performed under laboratory conditions with natural light and the average temperature of 25±2ºC to study the effect of magnetized water on maize seed germination and emergence. Four types of irrigation water such as tap, saline, canal, and sewerage water was used in the present study. Ground water was available in good quality and designated as tap water. Saline water of 1,500 ppm was prepared in laboratory by adding NaCl. Canal water was obtained from Bambawali-Ravi-Bedian (BRB) canal, Lahore branch, and sewerage water was collected from WASA tube-well located in Begum-pura Lahore. Various water types were treated before applying to the plants with 235 mT magnetic field at 3 lpm flow rate. Criteria used in selecting the 235 mT magnetic were its availability in market at cheaper rate. Use of 3 lpm flow rate during experimentation was due to capacity of small pump and laboratory experimental arrangement. Strength of magnetic field was produced just before the flow outlet using pairs of neodymium block magnets fixed to wooden frame 25 mm apart, each magnet measured 45 mm long, 5 mm high and 35 mm wide and a 90 mm pipe length was in contact with the magnets. Two magnets were placed on the upper side and two on lower side of pipe as shown in Figure 1. Strength of the magnetic field was



(a) Front view (b) Side view

Figure 1. Magnet arrangement in water flow pipe.

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measured along the longitudinal directions of the pipe with the help of magnetic flux meter and the maximum magnetic intensity was observed in the middle and the minimum magnetic intensity at the edge of the magnet and the joint point of the two magnets.

Maize seeds were grown in a washed sand culture for 15 days. The sand was washed thoroughly 3 to 4 times with tap water and finally with distilled water to remove the micro-nutrient, finer particles, mud, and any other distant material. The sand was air-dried and passed through a set of sieves having holes of 0.8 mm diameter (upper sieve) and 0.05 mm diameter (bottom sieve) to ensure uniformity of sand particles. The sand retained on the bottom sieve was used as sand culture and 1,000 g of this sand was placed in plastic pots (152 mm long, 101 mm wide and 76 mm deep). Uniform size seeds were used for germination test and examined with naked eyes for any kind of damage or spoiled before placing into sand pot. Seeds were soaked in magnetized water for 24 hours and fifteen seeds were placed in a grid of 3×5 with uniform interval and sown at a uniform depth of 20 mm in every pot with the help of marked stick. A measured volume of 240 ml water /pot, with or without magnetic treatment was applied in specified pots soon after sowing. The number of seedlings emerged was counted on daily basis in each pot during the entire duration of the study to determine the germination rate and emergence percentage. The emergence of seedlings was completed within 10 days of sowing; however, experiment was continued for another 5 days to observe differences in seedlings growth and weight. Three replications were made for each water type and were averaged for more precise results.

Data Analysis

Several seedling emergence parameters were analyzed to evaluate the effectiveness of magnetized water on maize seeds i.e. germination rate, seedling height and weight, final emergence percentage (FEP), emergence index (EI), emergence rate index (ERI) and mean emergence time (MET). The brief description of these parameters is presented below:

Final Emergence Percentage (FEP)

Final emergence percentage was calculated after fifteen days at the end of experiment by using simple percent formula.

$$FEP = \frac{Total\ number\ of\ seedlings\ emerged\ _{15}\ DAP}{Total\ number\ of\ seeds\ planted} \times 100 \quad (1)$$

Mean Emergence Time (MET)

Mean emergence time (MET) was calculated according to the equation of Ellis and Roberts (1981).

$$MET = \frac{\Sigma\, Dn}{\Sigma\, n} \quad (2)$$

Where, *D*= Number of days counted from the beginning of emergence, *n*= Number of seed emerged on day *D*.

Emergence Index (EI)

Speed of germination index was calculated as described by association of official seed analysis AOSA (1983):

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$$EI = \frac{Number\ of\ emerged\ seeds}{Days\ of\ first\ count} + \text{- - - - - - - - - -} \frac{Number\ of\ emerged\ seeds}{Days\ of\ final\ count} \quad (3)$$

Emergence Rate Index (ERI)

Emerged seeds were counted daily and used to calculate emergence rate index (ERI).

$$ERI = \sum_{n=first}^{Last} [\%n - \%(n-1)] / n \quad (4)$$

Where, *%n*= Percent of plants emerged on day n; *%(n-1)* = Percent of plants emerged on day *n-1; n*= Number of days after planting; First = First day any plants emerged, Last= Last counting day (emergence complete).

RESULTS AND DISCUSSION

Germination Rate

Seed germination rate is an important parameter for analyzing the initial growth of seed under laboratory condition and also useful to evaluate the effectiveness of any particular endeavor to enhance the crop yield. Pictorial views of maize seed germination with the application of various types of magnetized water in contrast to non-magnetized water are shown in Figure 2. It was observed in the

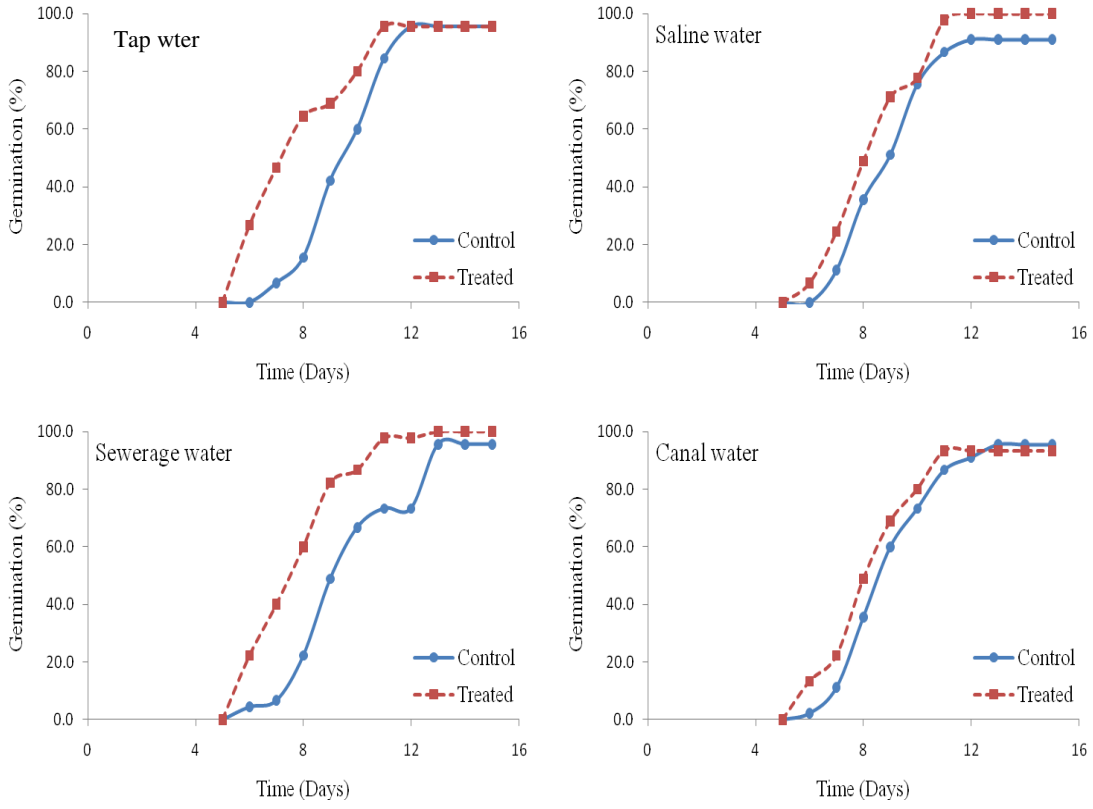

Figure 2. Percent germination rate of maize seeds for various types of magnetically treated water in comparison with the control.

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experiment that seed germination started one to two days earlier with the application of magnetized water as compared to non-magnetized water for tap, saline, and canal water. However, germination started on the same day with sewerage water either magnetized or non-magnetized. The maximum percent germination occurred after 10 to 12 days, as shown in Figure 2, and remained constant onward. Results indicated that germination completed two to three days earlier with magnetically treated tap, saline, and canal water as well as sewerage water. It is interesting to note that overall germination rate was higher with all types of magnetized water in comparison with non-magnetized water. But, on comparing magnetized types of water, germination rate with the magnetized saline and canal water was relatively less significant as compared to magnetized tap and canal water.

Results are in agreement with the germination data of maize seeds obtained by Aladjadjiyan (2002) as well as Podleoeny *et al.* (2004) that marked the positive effect of magnetic treatment on the germination and emergence of two broad bean cultivars. Higher germination rate may be due to effect of magnetic treatment on the amount and rate of water absorption in the maize seed cell membrane compared with the control. Magnetic field induced changes in ionic concentration and osmotic pressure, which regulates the entrance of water into the seeds. These beneficial effects of magnetic treatment of several water types illustrated in the present study may be due to some alterations within plant systematic biochemical level and their possible effects at cell level and mainly due to increased water content. External electric and magnetic fields have been reported to influence both the activation of ions and polarization of dipoles in living cells (Moon and Chung, 2000).

Seedling Height and Weight

The average height and weight of the maize seedlings measured after 15 days is presented in Table 1. The observed data allow us to distinguish difference between impacts of magnetized water on seedlings growth parameters subjected to various water types. With the application of magnetized water, the maize seedling grew taller and heavier as compared to control treatment. An increase of 13.87, 10.24 and 15.26% in seedling height and 17.09, 20.1, 17.4, 24.8 and 21.3% increase in seedling weight were noted with magnetized tap, saline, sewerage and canal water, respectively, in comparison to the control. Maximum increase in seedling height was observed with the application of magnetized canal water whereas magnetically treated sewerage water conferred more effectual results for seedling weight. This increase in seedling height and weight may be due to earlier emergence of maize seedling

Table 1. Maize seedling height and weight subjected to various magnetically treated waters compared to the control treatment after 15 days.

Water Type	Treatment	Seedling growth parameters			
		Height		Weight	
		Measured	Increase	Measured	Increase
		cm	%	gm	%
Tap	Control	2.36	13.87	10.4	20.1
	Treated	2.74		13.0	
Saline	Control	1.99	10.24	9.3	17.4
	Treated	2.21		11.3	
Sewerage	Control	2.81	15.26	11.0	24.8
	Treated	3.32		14.7	
Canal	Control	3.07	17.09	10.8	21.3
	Treated	3.71		13.8	

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irrigated with magnetized water in contrast to the control and, as a result, seedlings had two to three more days for growth compared with control treatment.

Emergence Indicators

Effects of magnetically treated water on seedling emergence are presented in Table 2. Various parameters were examined in the present study including final emergence percentage (FEP), emergence index (EI), emergence rate index (ERI) and mean emergence time (MET). Table 2 indicates that the magnetized waters have potential for rapid emergence and mean emergence time reduction for maize seeds. It was observed that magnetically treated water had significant effects on emergence indicators for various water types. *FEP* with magnetically treated canal water was less as compared to the control, whereas magnetized tap water had no effect on *FEP*. Higher value of *EI* and *ERI* symbolized the uniform and quick emergence. Results shown in Table 2 substantiate the significant increase in *EI* and *ERI* that clearly indicate rapid and uniform seed emergence. Emergence index was increased from 4.38 to 6.53, 5.21 to 6.54, 5.50 to 8.92, and decreased from 6.48 to 5.35, whereas emergence rate index increased from 9.95 to 12.54, 10.20 to 11.85, 10.06 to 12.84, and from 10.67 to 11.37 with magnetically treated tap, saline, sewerage, and canal water, respectively. Another important parameter of seed emergence is the *MET* that represents the time required for emergence. Higher *MET* values indicate more time required for seed emergence. Applications of magnetically treated water of various types for maize seed irrigation have realistic results on *MET* (Table 2). Magnetically treated water reduces the *MET* from 9.81 to 8.00, 9.15 to 8.73, 9.91 to 8.13 and from 9.23 to 8.50 for tap, saline, sewerage, and canal, respectively.

Present findings are in agreement with Podleoeny *et al.* (2004) who reported the beneficial effects of magnetic treatment on seed germination, emergence rate, and seed yield, and plant emergence was more regular after the use of the magnetic treatment and the emergence occurred 2–3 days earlier in comparison with the control treatment. Smirnov (2003) noticed that water can receive signals produced from magnetic forces that have a direct effect on living cells and their vital action.

Table 3 presents the percent increase or decrease due to the application of magnetized water compared with control water. Magnetic treatment of sewerage water conferred more positive effects on maize seedling emergence with 62% and 27.63% increase in *EI* and *ERI* and 17.90% decrease in *MET*. Johan *et al.* (2004) explained that magnetic technology was a promising treatment that could enhance the

Table 2. Effects of different types of magnetized water on seedling emergence.

Water type	Treatment	Seedling emergence indicators			
		Final emergence percent	Emergence index	Emergence rate index	Mean emergence time
		%			Days
Tap	Control	95.56	4.38	9.95	9.81
	Treated	95.56	6.53	12.54	8.00
Saline	Control	91.11	5.21	10.20	9.15
	Treated	100.00	6.54	11.85	8.73
Sewerage	Control	95.56	5.50	10.06	9.91
	Treated	100.00	8.92	12.84	8.13
Canal	Control	95.56	6.48	10.67	9.23
	Treated	93.33	5.35	11.37	8.50

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Table 3. Impacts of various magnetically treated water on emergence parameters.

Water type	Percent increase/Decrease in seedling emergence parameters			
	Final emergence percent	Emergence index	Emergence rate index	Mean emergence time
	%	%	%	%
Tap	0.00	48.86	26.03	-18.48
Saline	9.76	25.56	16.18	-4.52
Sewerage	4.65	62.00	27.63	-17.90
Canal	-2.33	-17.53	6.57	-7.93

separation of suspended particles from the sewage. In general, it is concluded that various water types had beneficial effects when magnetized.

Irrigation with magnetically treated water and seed absorption of magnetized water before sowing may be responsible for activations of enzymes and hormones involved in the germination process and mobilization of nutrients. As a result, there is probably an enhancement in the mobilization and transportation of nutrients to the embryonic axis and a resultant increase in speed of emergence and germination rate of maize seedlings. The authentication of these mechanisms, whether there is an activation of enzymes and hormone production within seeds due to the magnetized water, is beyond the scope of this study and necessitates further research.

CONCLUSIONS

Results of the present laboratory scale experiments revealed few beneficial effects of magnetically treated tap, saline, sewerage, and canal water for maize seed germination in sand culture. Irrigation with magnetically treated water resulted in significant increase in seedling height up to 13.87, 10.24, 15.26, and 17.09% and increase of 20.1, 17.4, 24.8, and 21.3% in seedling weight for tap, saline, canal, and sewerage water, respectively, compared with non-magnetized water. Magnetic water treatment improved the seedling *EI* from 4.38 to 6.53, 5.21 to 6.54, 5.50 to 8.92, and decreased from 6.48 to 5.35 for tap, saline, sewerage, and canal water, respectively, compared with the control. Similarly, there was improvement in the *ERI* from 9.95 to 12.54, 10.20 to 11.85, 10.06 to 12.84, and from 10.67 to 11.37 for tap, saline, sewerage, and canal water, respectively, in comparison with the control. But, there was a reduction in *MET* from 1 to days due to the application of magnetized water. Although magnetic water treatment is an environmentally friendly technique and easy to handle, but further studies are needed to understand the mysterious mechanism behind magnetic treatment and in turning it into a technology for end user benefits.

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اثر کاربرد آب مغناطیسی روی سبز شدن بذر ذرت در بستر شنی

س. محمود، و م. عثمان

چکیده

در این پژوهش اثرهای کار برد آب مغناطیسی روی جوانه زنی بذر ذرت بررسی شد. آب از منابع مختلف شامل آب شیر، آب شور (۱۵۰۰ قسمت در ملیون)آب کانال، و آب فاضلاب از میدان مغناطیسی به قدرت ۲۳۵mT با سرعت جریان ۳ لیتر در دقیقه گذرانده شد. بذر ها به مدت ۲۴ ساعت دراین آبها خیسانده و سپس در بستر شنی کاشته شدند. تعداد جوانه ها روزانه شمارش شد و داده های رشد ۱۵ روز بعد از کاشت ثبت گردید.نشانگر های جوانه زنی از قبیل نمایه جوانه زنی(EI) نمایه نرخ جوانه زنی(ERI) و میانگین زمان جوانه زنی (MET) برای ارزیابی سبز شدن و جوانه زنی بذر ذرت به کار رفتند.نتایج مطالعه حاضر آشکار ساختند که کار برد آب مغناطیسی جوانه زنی بذر ذرت را بهبود بخشید.در مورد آب مغناطیسی در مقایسه با

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آب غیر مغناطیسی، نمایه جوانه زنی از مقادیر ۵.۵ به ۸.۹ و نمایه نرخ جوانه زنی از ۱۰.۰۶ به ۱۲.۸۴ افزایش یافتند و میانگین زمان جوانه زنی به مقدار ۱۷.۹٪ کاهش یافت. در تمام انواع آب آزمون شده، تیمار آب مغناطیسی رشد سریعتر وسنگین تری نشان داد. به طور کلی، حد اکثر افزایش طول و وزن گیاهچه ها (بوته ها) در تیمار فاضلاب مغناطیسی شده مشاهده شد.از آنجا که این نتایج بر مبنای مقیاس محدود مطالعه آزمایشگاهی به دست آمده اند، پیشنهاد می شود قبل از ارایه توصیه قوی در این مورد، آزمون های بیشتری روی کاربرد آب مغناطیسی برای آبیاری اجرا شود.

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