*Journal of Research in Forestry, Wildlife & Environment Vol. 8(4) December, 2016*
**http://www.ajol.info/index.php/jrfwe**
*jfewr ©2016 - jfewr Publications*
E-mail:jfewr@yahoo.com
*ISBN: 2141 – 1778*
*Yusuf et al., 2016*


# EFFECTS OF MAGNETICALLY TREATED WATER ON GERMINATION AND GROWTH OF TOMATO (*LYCOPERSICON ESCULENTUM: VARIETY UC82B*) UNDER POOR SOIL FERTILITY AND DEFICIT IRRIGATION

***Yusuf[1], K. O, Ogunlela, A. O and Murtala, M. O**

Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria
*Corresponding e-mail: yusuf.*ok@unilorin.edu.ng/kamaru.yusuf@yahoo.com*

***ABSTRACT***

***This study was conducted to evaluate the effect of magnetically treated water on the survival of tomato plant after germination and growth of the tomato plant under deficit irrigation and poor soil fertility. The soil used in this study was sieved through 2 mm sieve to have a uniform soil particle sizes and to remove some organic matter that was yet to decompose. Water from the University of Ilorin dam was used for irrigating the tomato (Lycopersicon Esculentum: variety UC82B) plant. The water was allowed to pass through magnetic treatment pipe for duration of 113 s. The mean magnetic flux density used was 719 gauss (G) measured inside the pipe. The treatments ($T_1$ to $T_5$) were 100 %, 80 %, 60 %, 50 % and 40 % of the water requirement by tomato and each treatment was replicated 5 times. Experimental layout used in this study was a completely randomized design (CRD) with a control experiment set up adjacent to it in the same transparent garden shed. The results showed that tomato plant irrigated with magnetically-treated water exhibited resistance to water stress, poor soil fertility and fungal attack with 52 % surviving after germination while only 24 % of tomato plants survived after irrigation with non–magnetically treated water. The heights of tomato plants using the treated water with $T_1$ to $T_5$ were 548 mm, 381 mm, 342 mm, 301 mm and 286 mm, respectively while those of untreated water were 512 mm, 365 mm, 326 mm, 298 mm and 264 mm, respectively.***

**Keywords:** irrigation, magnetically treated water, magnetic water, tomato

## INTRODUCTION

Magnetic treatment of water is a modern technology in Agriculture and a non – chemical method of water treatment to soften the water, boost crop yield, improve crop quality and enhance effective utilization of the arable land. The method is environmentally friendly (Kozic *et al.,* 2006). Aladjadjiyan (2007) reported that the magnetically treated water induced seed germination, shoot development and increased crop yield. When the seeds were passed through a magnetic field, the germination rate of seeds, seedling growth rate, reproduction and growth of the meristem cells and chlorophyll were improved (Renia *et al*., 2001). (Yinan *et al.* 2005) indicated that the pretreatment of cucumber seeds through a magnetic field would stimulate the growth and development of cucumber seedlings. Helal (2010) also reported that the effect of magnetic field increased the activities of antioxidant enzymes, photosynthetic activity and photosynthetic pigments consequently enhanced the plants growth and productivity. Anand *et al.* (2012) indicated that magnetic treatment of irrigation water can alleviate adverse effect of water stress in crop because it reduces free radicals production and antioxidant enzymes activity.

Magnetic treatment of irrigation water increased yield, saves water, early maturity of crop, reduced plant diseases, improved crop quality, increased fertilizer efficiency and reduced the cost of farm operations (Babu, 2010; El-Sayed and Sayed, 2014; Hoszyn and Abdul- Qados, 2010; Maheshuwari and Grewal, 2009; Selim, 2008; Suchitra and Babu, 2011;). Magnetic treatment of water actually change the structure of water thereby reducing the surface tension of the water, increased minerals dissolvability of water and provided adequate nutrients for plant growth (Babu, 2010). When water passes through the magnetic 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). To reclaim soil with the limited available water, and to reduce soil salinity, magnetically treated water can be used (Kney and Parsons 2006).

Kochmarsky (1996) indicated that the effective magnetic flux density for water treatment ranging from 1000 to 6000 G. Chern (2012) used a permanent magnet with magnetic field strength of 5500 G for treating irrigation water which was used to irrigate lady's finger moench plant and the effect on plant growth and yield was significant. Maheshwari and Grewal (2009) monitored and recorded the magnetic flux densities inside the treatment pipe where the actual treatment occurs and the values of magnetic field strength obtained ranged from 35 to 1360 G. They pointed out that the magnetic field intensity used had significant effect on the yield of snow pear and celery plants.

**Objectives of the study**

The specific objectives of this study were to:

(i) tetermine the effect of magnetically treated water on the survival of tomato plant after germination using deficit irrigation.

(ii) assess the effect of magnetically treated water on vegetative growth of tomato plant.

## MATERIALS AND METHODS

**Study Area**

The study was conducted between 4$^{th}$ February, 2014 and 30$^{th}$ April, 2014 at the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria. Ilorin lies on the latitude 8$^{o}$30$^{1}$ and longitude 4$^{o}$35$^{1}$E at an elevation of about 340 m above mean sea level (Ejieji and Adeniran, 2009). Ilorin is the southern guinea savannah ecological zone of Nigeria with annual rainfall of about 1300 mm. The wet season begins towards the end of March and ends in October while the dry season starts in November and ends in March (Ejieji and Adeniran, 2009 and Ogunlela, 2001). The relative humidity inside the garden during the study between February 2014 and April 2014 varied from 45 to 65 %.

**Magnetic Treatment of Water and Experimental set up**

Magnetic field used for the treatment of irrigation water in the study was generated from an electromagnet. The electromagnet was fabricated using locally available materials in Ilorin, Nigeria. The magnetic flux density used in this study was 4310 G (between two magnetic cores) with 12 V terminal but the effective mean magnetic flux density inside the treatment pipe was 719 G. The treatment chamber was a transparent rectangular pipe with an internal dimension of 15 mm (breath) and 46 mm (height). The rectangular pipe was 3000 mm long.

The treatments ($T_1$, $T_2$, $T_3$, $T_4$ and $T_5$) were 100%, 80 %, 60 %, 50 % and 40 % of the water requirement by tomato. The values of 40 and 50 % of water requirement were used in the treatment so that the tomato plant could be subjected to or experienced deficit irrigation (water stress). The soil used in this study was loamy sand and sieved through a 2 mm sieve to remove the organic matter that had not decomposed in the soil to prevent the organic matter from improving the soil fertility. Water from the University of Ilorin Dam was used to irrigate the tomato plants after being treated by magnetic field of 719 G.

A 5 by 5 CRD experimental layout was used in allocating treatments to the tomato planted in 25 buckets in a transparent garden shed. A control experiment was also set up at the adjacent to it in the same garden shed using CRD layout in 25 buckets. The soil used in this study was loamy sand with Chemical properties of the soil are shown in Table 1. The soil type, tomato seed variety and the computed water requirement for the tomato in this study are shown in Table 2. The north and south poles of the electromagnetic cores on the treatment chamber seat in this study were in alternated form for effective treatment of the irrigation water by the magnetic field (McMahon, 2009). The irrigation water was allowed to pass through three treatment chamber units four (4) times for duration of 113 s. Circulation flow method of the water through the magnetic treatment chamber shown in Figures 1 and 2 as suggested by Chern (2012).

**Table 1** Chemical properties of the soil used

| **Chemical** | **Mean value** |
|---|---|
| pH | 6.27 |
| N (%) | 0.29 |
| P (mg/kg) | 5.22 |
| $Ca^{2+}$ (cmol/kg) | 1.64 |
| $Mg^{2+}$ (cmol/kg) | 0.75 |
| $K^{+}$ (cmol/kg) | 1.46 |
| $Fe^{2+}$ (cmol/kg) | 0.58 |
| $Na^{+}$ (cmol/kg) | 0.65 |
| Zn (ppm) | 1.25 |

**Table 2** Soil type, tomato seed variety and water requirement parameters

| **Soil and plant parameters** | **Value** |
|---|---|
| Tomato (*Lycopersicon Esculentum)* variety | UC 82B |
| Duration | Three months |
| Reference evapotranspiration, ETo (mm/day) | 5.5 |
| Crop coefficient, $k_c$ | 1.05 |
| Crop evapotranspiration, ETc (mm/day) | 5.78 |
| Number of tomato stands in a bucket after thinning | 2 |
| Soil type used | loamy sand |
| Soil Field capacity (%) | 22.04 |
| Wilting point (%) | 10.02 |
| Soil bulk density ($g/cm^3$) | 1.546 |
| Depth of soil in the bucket (mm) | 190 |
| Available water for plant (mm) | 35.31 |
| Net depth of irrigation at 50% depletion (mm) | 17.66 |
| Irrigation interval (day) | 3 days |
| Area of the bucket ($m^2$) | 0.0314 |
| Vol. of water required at 100% (litres) | 1.1 |
| Vol. of water required at 80% (litre) | 0.9 |
| Vol. of water required at 60% (litre) | 0.7 |
| Vol. of water required at 50% (litre) | 0.6 |
| Vol. of water required at 40% (litre) | 0.44 (0.5 was used) |

**Figure 1** Electromagnetic treatment equipment.

**Figure 2** Magnetically treated water from the electromagnet.

**Determination of water requirement by the tomato and irrigation interval**

Water requirement of tomato plant is the amount of water required to meet the required evapotranspiration, photosynthesis and metabolic processes. Crop evapotranspiration, depth of water required to bring the soil to field capacity at the beginning of the experiment, available water, wilting point, net depth of irrigation, irrigation interval, volume of water required daily by tomato plant and volume required in three (3) days irrigation interval for two stands of tomato plant were determined using Equations (1), (2), (3), (4), (5), (6) and (7) respectively. The value of wilting point used was determined from Equation (4) reported by Sani (2003). A measure of 1.1litres of water was determined as the water required by two stands of tomato plant for 3 days irrigation interval at 100 % and 0.44 litre at 40 %.

$$ETc = K_c \times ET_o \qquad \text{.....................(1)}$$

$$D_F = \frac{\rho_b}{\rho_w}\left(\frac{FC - \Theta_1}{100}\right)D_b \qquad \text{............(2)}$$

$$AW = \frac{\rho_b}{\rho_w}\left(\frac{FC - WP}{100}\right)D_b \qquad \text{............(3)}$$

$$WP = \frac{FC}{F} \qquad \text{.............. (4)}$$

$$d_n = P_n \times AW \qquad \text{...............(5)}$$

$$I_v = \frac{d_n}{ETc} \qquad \text{...............(6)}$$

$$V_P = P_n \times A_P \times ETc \times I_v \times N_p \qquad \text{...........(7)}$$

where ETc is the crop evapotranspiration (mm/day), Kc is the crop coefficient (which was 1.05 at 80 % canopy cover), ETo is the reference evapotranspiration (which was 5.5 mm/day for peak value in March of the year in Ilorin), $D_F$ is the depth of water required to bring moisture content to field capacity at the beginning of the experiment (mm), $\rho_b$ is soil bulk density (g/cm$^3$), $\rho_w$ is the density of water (g/cm$^3$), FC is the field capacity of the soil (%), $\Theta$ is the moisture content of the soil prior to irrigation (%), $D_b$ is depth of the bucket (mm), Aw is the available water (mm), WP is the wilting point (%), F is a factor ranging from 2.0 – 2.4 depending on the percentage of silt in the soil. The value of F used was 2.2 and wilting point was calculated to be 10.02 % when field capacity (FC) was 22.04 %. $I_v$ is the irrigation interval (day), $d_n$ is the net depth of irrigation (mm), $V_p$ is the volume of water required by plants based on days of irrigation interval and number of stands of plant per hole/pot (litre/days), $C_c$ is the crop canopy (%), $A_p$ is the area of the bucket ($m^2$) and $N_p$ is the number of tomato stand in a bucket or point. Irrigation was done when 50 % of AW was depleted.

**Statistical analysis for vegetative growth of tomato plant by paired t–test**

Statistical analysis for the vegetative growth (height) of tomato plant was calculated using paired t–test method to know if the effect of magnetically treated water was statistically significant on the tomato plant height or not from the mean heights of the tomato plants irrigated by magnetically treated water (MTW) or non-magnetically treated water (NMTW). The difference between the two mean of the results was determined and then used to compute standard deviation, standard error and t–test value using Equations (8), (9a) or (9b), (10) and (11), respectively as given by Montgomery *et al.,* (1998).

$$\bar{d} = \frac{\sum d}{n} \quad \text{……………………}(8)$$

$$\delta = \sqrt{\frac{\sum \left(d - \bar{d}\right)^2}{n-1}} \quad \text{…………..}(9a)$$

$$\delta = \sqrt{\frac{\sum d^2 - n\left(\bar{d}\right)^2}{n-1}} \quad \text{………..}(9b)$$

$$\delta_{Er} = \frac{\delta}{\sqrt{n}} \quad \text{…………...}(10)$$

$$t_{cal} = \frac{\bar{d}}{\delta_{Er}} \quad \text{…………… }(11)$$

where $\bar{d}$ is the mean of the difference from the data $x_1$ and $x_2$, $\Sigma d$ is the summation of d, n is the number of the observations, $\delta$ is the standard deviation, $\delta_{Er}$ is the standard error and $t_{cal}$ is the calculated value of t which was compared with the Table value ($t_{Tab}$) obtained from Montgomery *et al.* (1998).

## RESULTS AND DISCUSSION

### Results

The results of this study revealed that magnetically treated water boosted the resistance of the tomato plant against diseases such as fungal attack and poor soil fertility. The tomato seed planted in the buckets irrigated by magnetically and non–magnetically treated water germinated after one week and percentage germination are shown in Table 3. The percentage germination of tomato seeds was higher with tomato irrigated with magnetically treated water than the tomato irrigated with non-magnetically treated water. The tomato plants were attacked by fungal disease between 4 and 5 weeks after germination because the soil was not treated before planting the tomato seed with fungicide. The plant could not also obtain enough nutrients for metabolic process because the soil used was not fertile and water shortage due to partial supply of water below the water requirement (deficit irrigation) also affected the growth of tomato. The stem girth and vegetative growth of tomato plants in this study are shown in Tables 4 and 5. The stem girth and vegetative growth of tomato plants are also shown in Figures 3 and 4.

**Table 3** Percentage germination tomato seeds after a week of planting

| Treatment | Germination rate (%) | |
|---|---|---|
| | **Magnetically treated water** | **Non–magnetically treated water** |
| $T_1$ | 90 | 85 |
| $T_2$ | 70 | 67 |
| $T_3$ | 75 | 55 |
| $T_4$ | 60 | 50 |
| $T_5$ | 55 | 45 |

$T_1$ = 100 % water requirement applied, $T_2$ = 80 %, $T_3$ = 60 %, $T_4$ = 50 % and $T_5$ = 40 %.

**Table 4** Tomato stem girth irrigated with magnetically and non–magnetically treated water at 8 weeks.

| Treatment | Tomato plant stem thickness (mm) | |
|---|---|---|
| | MTW | NMTW |
| T1 | 9.0 | 9.0 |
| T2 | 9.0 | 8.5 |
| T3 | 8.5 | 8.0 |
| T4 | 7.5 | 6.5 |
| T5 | 7.0 | 6.0 |

MTW = magnetically treated water, NMTW = non–magnetically treated water
T1, T2, T3, T4 and T5 as explained in Table 3

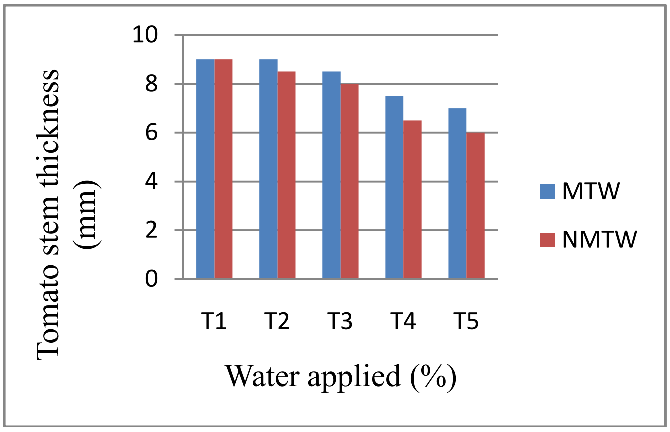


**Figure 3** Tomato plant stem girth (mm) with different treatments MTW, NMTW, T1, T2, T3, T4 and T5 as explained in Table 3.

**Table 5** Tomato plant height irrigated with magnetically treated and non – magnetically treated water at 8 weeks.

| Treatment | Tomato plant height (mm) | |
|---|---|---|
| | Magnetically treated water | Non–magnetically treated water |
| T1 | 548 | 512 |
| T2 | 381 | 365 |
| T3 | 342 | 326 |
| T4 | 301 | 298 |
| T5 | 286 | 264 |

T1, T2, T3, T4 and T5 were as explained in Table 3

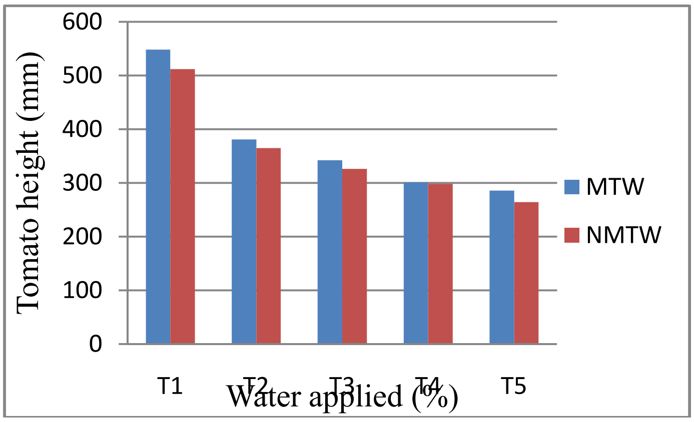


**Figure 4** Tomato plant height (mm) with different treatments MTW, NMTW, T1, T2, T3, T4 and T5 as explained in Table 3

## DISCUSSION

The percentage germination of tomato seeds was higher with tomato plants irrigated with magnetically treated water than the tomato irrigated with non-magnetically treated water. The tomato plants were attacked by fungal disease between 4 and 5 weeks after germination because the soil was not treated before planting the tomato seed with fungicide. The plant could not also obtain enough nutrients for metabolic process because the soil used was not fertile and water shortage due to partial supply of water below the water requirement (deficit irrigation) also affected the growth of tomato. Fungal attack, water stress and poor soil fertility led to destruction of some tomato plants after 4 weeks of planting. Tomato plants irrigated with non–magnetically treated could not withstand the stress with 24 % (6 buckets out of 25) survived but tomato plant irrigated with magnetically treated water had 52 % (13 buckets out of 25) tomato plant that survived despite the water stress poor soil fertility and fungal attack as shown in Table 3. Magnetically treated water seemed to boost the resistance of the tomato plant against water shortage (deficit irrigation) after germination and under poor soil fertility which was in agreement with the study of Anand *et al*. (2012). The stem girth and vegetative growth of tomato plants in this study were shown in Tables 4 and 5. Tomato plant irrigated with magnetically treated water (MTW) performed better with bigger stem thickness under soil poor fertility and deficit irrigation than the non–magnetically treated water (NMTW) which was in agreement with the work done by Anand *et al*. (2012) that magnetically treated water alleviate adverse effect of water stress which crop could undergo by deficit irrigation. Magnetically treated water also increased vegetative growth (tomato plant height) of tomato which was in agreement with work conducted by some other researchers like Babu (2010), Maheshwari and Grewal (2009) and Moussa (2011). Again, tomato plant supplied with 100% of water requirement irrigated by magnetically treated water grew faster and had highest height of 548 mm compared to that of tomato irrigated by non-magnetically treated water with corresponding height of 512 mm as shown in Table 5. The calculated value of t ($t_{cal}$) was 3.480 while table vale of t ($t_{Tab}$) 2.776. The effect of MTW was statistically significant on the mean values of the tomato plant heights computed by the paired t–test compared to the heights of tomato plant irrigated by NMTW.

## CONCLUSION

Magnetic treatment of irrigation water boosted the resistance of tomato plant against diseases and plants survived under poor soil fertility. Magnetically treated water increased the vegetative growth of tomato plants and the effect of MTW on tomato plant growth was statistically significant compared to the growth of tomato plants irrigated with NMTW.

## RECOMMENDATIONS

1. The use of magnetically treated water for crop improvement is a promising technology because it is a non–chemical method for agriculture and it is environmentally friendly.
2. More research should be conducted into the effect of magnetically treated water on the vegetative growth and yield of some crops using different magnetic flux densities.
3. The influence of magnetically treated water on the uptake of heavy metals (lead,

cadmium, arsenic, copper, zinc and mercury) by crops that can cause certain diseases to man should also be studied to know if the technology add or reduces some of these heavy metals to crops so that the crop can be consumed without causing any disease to man.

## REFERENCES


Aladjadjiyan, A. (2007): The use of physical methods for plant growing stimulation in Bulgaria. Journal of Central European Agriculture, 8 (3): 369-380.

Anand, A., Nagarajan, S., Verma, A. P. S., Joshi, D. K., Pathak, P. C. and Bhardwaj, J. (2012): Pre – treatment of seeds with static magnetic field ameliorates soil water stress in seedling of maize (Zea mays L.)Indian Journal of Biochemistry and Biophysics, 49 (1): 63 – 70.

Babu, C. (2010): Use of magnetic water and polymer in agriculture. Tropical Research, D 08 – 806 – 001.

Chern, C. C. (2012): Application of magnetic water to stimulate the lady's finger (Abelmosculentus L.) moench plant growth. B. Eng. Thesis University of Technology, Malaysia.

Ejieji, C. J and Adeniran, K. A. 2009. Effect of water and fertilizer stress on the yield, fresh and dry matter production of grain amaranth. *Australian Journal of Agricultural Engineering,* 1(1):18-24.

El - Sayed, H. and Sayed A. (2014) Impact of magnetic water irrigation for improve the growth, hemical composition and yield production of broad bean (*Vicia faba* L.) Plant. American Journal of Experimental Agriculture, 4(4): 476-496.

Helal, R. M., (2010). The impact of magnetic water application for improving common bean (*Pheseolus Vulgaris L*) production. New York Science Journal, 4 (6):15-20.

Higashitani K., A. Kage, S. Katamura, K. Imai, S. Hatade, (1993). Effects of a magnetic field on the formation of CaCO3 particles. *Colloid and Interface Science.*1993, 156(1):90-95.

Hozayn, M. and Abdul- Qados, A. M. S.(2010) Irrigation with magnetized water enhances growth, chemical constituent and yield of chickpea (Circer arietinum L.). Agriculture and Biology Journal of North America, 1(4): 671 – 676.

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.

Kochmarsky, V. (1996) Magnetic treatment of water: possible mechanisms and conditions for applications. Magnetic and Electrical Separation, 7: 77-107.

Kozic, V., Krope, J., Lipus, L.C., and Ticar, I., (2006). Magnetic field analysis on electromagnetic water treatment, Hungarian journal of industrial chemistry Veszprem. 34: 51-54.

Maheshwari, R. L. and Grewal, H. S (2009) Magnetic treatment of irrigation water: its effects on vegetable crop yield and water productivity. Journal of Agricultural Water Management, 96 (8) :1229-1236.

McMahon, C. A. (2006) Investigation of the quality of water treated by magnetic fields. B. Eng. Thesis University of Southern Queensland.

Montgomery, D. C., Runger, G. C., Hubele, N. F (1998): Engineering statistics. John Wiley and Sons, Inc, New York: 135 – 248.

Moussa, H. R. (2011) The impact of magnetic water application for improving common bean (*Phaseolus vulgaris* L.) production. New York Science Journal, 4(6): 15 – 20.

Ogunlela, A.O (2001) Stochastic Analysis of Rainfall Events in Ilorin, Nigeria. Journal of Agricultural Research and Development. Faculty of Agriculture, University of Ilorin.

Renia F.G., Pascual L.A., Fundora I.A. (2001) Influence of a Stationary Magnetic Field on water relations in 68 lettuce Seeds. Part II: Experimental Results. Bioelectromagnetics 22:596-602.

Selim, M. M (2008) Application of Magnetic Technologies in Correcting Under Ground Brackish Water for Irrigation in the Arid and Semi-Arid Ecosystem, The 3rd International Conference on Water Resources and Arid Environments, and the 1st Arab Water Forum.

Suchitra, K. and Babu, E. A. (2011) A pilot study on silt magnetized and non-magnetized water in the on-farm water use efficiency management. Centre for Water Resources, Anna University, Chennai, India.

Yinan, L., Yuan, L., Youngquing, Y. and Chunyung , L. (2005). Effect of seed pretreatment by magnetic field on the sensitivity of cucumber (*cucumus sativus*) seedlings to ultraviolet-B radiation. Environmental and Experiment Botany (54): 286-294.