Effect of Magnetically Treated Water on Precipitation of some Macro Elements in the Soil for Tomato Growth

*Kamarudeen O. Yusuf and Ayodele O. Ogunlela

1Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria

Abstract- This study was conducted to determine effect of magnetically treated water (MTW) on the precipitation of some macro elements in the soil for tomato growth. Magnetic flux densities used for treating the water were 124, 319 and 719 gauss (G) produced from electromagnet with direct current. A 1.0 litre of MTW was added to sandy loam in a bucket at 3 days interval for 45 days. Each treatment was replicated 3 times and a control experiment in which the soil was treated with 1.0 litre of non–magnetically treated water (NMTW) and replicated 3 times. The mean concentrations of calcium, potassium, sodium, nitrogen, phosphorus, organic matter and organic carbon for MTW treated using 719 G were 3.16 cmol/kg, 2.67 cmol/kg, 1.58 cmol/kg, 0.97 %, 2.39 mg/kg, 2.41 % and 1.39 %, respectively while the corresponding values for NMTW were 2.82 cmol/kg, 2.35 cmol/kg, 1.42 cmol/kg, 0.87 %, 2.26 mg/kg, 2.30 % and 1.32 %. MTW treated by 124 G also gave higher values of concentrations macro elements than the values from soil treated with NMTW. The influence of MTW by 124, 319, 719 G and NMTW on mean heights of tomato plant (growth) at 26 days after planting were 154.3, 178.6 and 190.3 and 137.1 mm, respectively. Mean diameter of the tomato stem at 30 mm above soil level for 124, 319, 719 G and NMTW at 49 days after planting were 8.64, 7.99, 8.21 and 6.96 mm, respectively.

Keywords- Magnetically treated water, macro elements, paired t-test, soil

1 INTRODUCTION

Magnetically treated water also called magnetized water or magnetic treatment of water is a non–chemical method for crops improvement and prevention of carbonate deposition in pipe. The technology is new in Nigeria and there is need to conduct series of research on the effect of magnetic treatment of water on the chemical properties of water, its effect on chemical properties of soil and how it enhances precipitation or release of chemicals from the soil for plant growth. The research on MTW would increase understanding and mechanism of how the technology improves crop yield. Magnetic treatment of irrigation water has many benefits in agriculture such as increase yield, saves water, early maturity of crop, reduced plant diseases, improved crop quality, increased fertilizer efficiency and reduced cost of farm operation (Podlesny, Pietruszewski and Podleœena, 2004; Maheshwari and Grewal, 2009; Babu, 2010; Hozayn and Abdul-Qados, 2010; El-Sayed and Sayed, 2014).

Magnetic field actually change the structure of water thereby reducing the surface tension of the water, soften the water, increase minerals dissolvability in water and hence provide adequate nutrients for plant growth (Babu, 2010). When water passes through magnetic field, its structure and some physical characteristic such as density and deposition ratio of solid particles would change (Higashitani et al., 1993). Noran et al. (1996) pointed out that the result of the influence of the magnetic field on solutes, the interaction between soil particles and salts dissolved in ordinary water does not resemble the interaction between the soil particles and the salts dissolved in magnetically treated water. Kochmarsky (1996) pointed out that the effective magnetic flux density for water treatment varied from 1,000 to 6,000 G. He also indicated that 4,000 to 5,000 G could attain the efficiency of 60 to 80% when applied on heater and low–pressure boilers.

Mdsa‘at (2006) and Chern (2012) used permanent magnet with magnetic field strength of 5,500 G for treating water which was used to irrigate lady’s finger moench plant (okra) and the effect on plant growth and yield was significant. Moussa (2011) indicated that magnetized water with 3,000 G could improve quantity (yield) and quality of common bean crop. 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 ranges 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. Moussa (2011) also pointed out that magnetically treated water could stimulate defense system, photosynthetic activity, and translocation efficiency of photoassimilates in common bean plants.

Water is a solvent that dissolves chemicals and plant nutrients present in the soil for plant growth. Poor water quality usually makes availability or precipitation of plant nutrients difficult from the soil for plant growth. Babu (2010) indicated that magnetically treated water increased dissolvability of water for soil plant minerals and plant can easily absorb magnetically treated water which contains more dissolved minerals than the ordinary water. Mohammed (2013) also pointed out that magnetically treated water play an important role in salts solubility which could increase cations and anions concentrations in the soil solution. The objectives of this study were to determine the effect of magnetically treated water on the precipitation (concentration) of macro elements from the soil and to determine the effect of MTW on growth and stem thickness of tomato plant.

2 MATERIALS AND METHODS

2.1 LOCATION OF THE STUDY AREA

The study was carried out at the Demonstration farm of Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Kwara State, Nigeria. Ilorin lies on the latitude 8°30′N and longitude 4°35′E at an elevation of about 340 m above mean sea level (Eijeji and...
Adeniran, 2009). Ilorin is in the Southern Guinea Savannah Ecological zone of Nigeria with annual rainfall of about 1,300 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 (Ogunlela, 2001).

### 2.2 Magnetic Flux Density used for Treating the Water and Soil used in the Study

Magnetic flux densities used for the treatment of the water in this study were 124, 319 and 719 G produced from the electromagnet. These three magnetic flux densities were within the range that could be used to treat irrigation water as stated by Maheshwari and Grewal (2009). The north and south poles of the electromagnetic cores on the rectangular treatment pipe seat in this study were alternated for effective treatment of irrigation water by the magnetic field (Gabrielli et al., 2000 as cited by McMahon, 2009). The water was allowed to pass through three treatment pipe for duration of 113 s in the pipe. The treatment unit was a rectangular plastic glass pipe with an internal dimension of 1.5 by 4.6 cm and 100 cm long. The raw water fetched from the University of Ilorin dam and it was allowed to flow through the electromagnet to become magnetically treated water after flowing through the magnetic field as shown in Fig. 1 and Fig. 2.

A total of 12 buckets having internal diameters of 263 mm and 235 mm depth with 5 holes (5 mm diameter) at the bottom for the passage of excess (drainage) water were used. Each bucket was filled with 13 kg of soil and magnetically treated water (1.0 litre) treated with 719, 319 and 124 G were applied to the soil at 3 days interval in a transparent garden shed for 45 days between 5th January and 20th February 2015. Soil treated with non–magnetically treated water (1.0 litre) as a control experiment was also put in the garden shed. Each treatment was replicated 3 times. Soil sample from each bucket was taken from 5 to 150 mm depth in the bucket for chemical analysis to know if the magnetically treated water has effect on the precipitation (concentration) of some elements from the soil or not.

The soil used in this study was loamy sand collected at the same place (point) from the top soil at the Demonstration farm of Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Kwara State, Nigeria. The soil was properly mixed after the soil particle size analysis was carried out in order to have uniform soil property. The soil was then filled into the bucket to a depth of 235 mm and the diameter of the bucket at that level was 263 mm \( (A_p = 0.05433 \text{ m}^2) \). A 13 kg of the loamy sandy soil was put in each bucket.

### 2.3 Determination of Chemical Properties of Soil

All the cations mainly Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), anions mainly Nitrogen (N), Phosphorus (P), Organic matter and Organic carbon of the soil treated with magnetic water (magnetically treated water) and non–magnetically treated water (control experiment) were determined using the standard methods given by Okalebo et al. (2002).
mean of the results was determined and then used to compute standard deviation, standard error and t-test value using Equations (1), (2a) or (2b), (3) and (4), respectively as given by Montgomery et al. (1998).

\[
\bar{d} = \frac{\sum d}{n}
\]

\[
\delta = \sqrt{\frac{\sum (d - \bar{d})^2}{n - 1}}
\]

\[
\delta_Er = \frac{\delta}{\sqrt{n}}
\]

\[
t_{cal} = \frac{d}{\delta_Er}
\]

where \(\overline{d}\) is the mean of the difference from the data \(x_i\) and \(x_0\), \(\sum d\) 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 of \(t_{cal}\).

### 2.6 Statistical Analysis for Tomato Plant Growth by CRD

The statistical analysis for tomato plant growth was determined to ascertain if the magnetically treated water has effect on the growth of tomato or not. Sum of square treatment, sum of square total, correction factor and sum of square error were determined using equations (5), (6), (7) and (8), respectively given by Gomez and Gomez (1984). The values SST\(_{r}\), SST\(_{o}\) and SSE were used to determine the Analysis of Variance (ANOVA) to ascertain if the effect of magnetically treated water is statistically significant on the tomato plant growth or not.

\[
SST_R = \sum \frac{T^2}{t} - C.F
\]

\[
SST_O = \sum X^2 - C.F
\]

\[
C.F = \frac{G^2}{N}
\]

\[
SSE = SST_O - SST_R
\]

where; SST\(_{r}\) is the sum of square treatment, SST\(_{o}\) is the sum of square total, \(T\) is the total output of the treatments, \(t\) is the number of treatments used or replication, \(X\) is the output of each treatment from the experiment, C.F is the correction factor, \(G\) is the grand total of the observation, \(N\) is the total of observation and SSE is the sum of square error.

### 3 Results and Discussion

#### 3.1 Effect of MTW and NMTW on Precipitation of Macro Elements in the Soil

The soil used was loamy sand whose mean percentage contents of sand, silt and clay were 8.67, 5.76 and 85.57 %, respectively. The mean concentration of chemical properties of the soil after 45 days on the soil treated with magnetically treated water (MTW) using three different magnetic flux densities 124, 319 and 719 G and non—magnetically treated water (NMTW) were shown in Table 1. The results of chemical analysis of the soil in Table 1 indicated that there was a slight increment in calcium content of the soil treated with magnetically treated water when compared to that treated with non-magnetically treated water. This result was in agreement with the results obtained by Mohammed (2013) that magnetically treated water play an important role in salts solubility which could increase cations and anions concentrations in the soil solution. The precipitation (concentration) of potassium, sodium, nitrogen, organic matter and organic carbon were slightly higher as shown in Table 1. These increment in concentration of some macro elements in the soil solution was in agreement with results obtained by Babu (2010) that magnetic field actually change the structure of water thereby reducing surface tension of the water, increased minerals dissolvability of water and provide adequate nutrients for plant growth. The precipitation (concentration) of calcium, potassium, nitrogen, organic matter and organic carbon from the soil treated with magnetically treated water were not statistically significant as shown in ANOVA Table 2. The increment in concentration of some of these chemicals from the soil could enhance vegetative growth and increase crop yield as stated by Maheshwari and Grewal (2009) and Selim (2010).

#### 3.2 Effect of MTW and NMTW on Growth, Stem Thickness and Yield of Tomato Plant

The effect of MTW on growth of tomato plant was determined by measuring the height of the tomato plant in each bucket five times during vegetative growth and compared with the height of tomato irrigated by NMTW. The heights of tomato plants irrigated by MTW for water treated with 124, 319 and 719 G were all higher than the heights of tomato irrigated by NMTW as shown in Tables 3, 4, 5, 6 and 7. This higher growth rate of the tomato irrigated with MTW was in agreement with the work of De Souza et al. (2005) and Dhawi (2014) that MTW normally accelerates enzyme related to auxin (plant hormone) reactions which could increase the growth rate and promote fruit ripening. The mean heights of tomato plant at 26 days after planting for MTW treated with magnetic flux densities 124 (T\(_1\)), 319 (T\(_2\)), 719 G (T\(_3\)) and NMTW (T\(_4\)) as showed in Table 3 were 154.3, 178.6, 199.3 and 137.1 mm, respectively. The growth rate measured at 47 days after planting for T\(_1\), T\(_2\), T\(_3\) and T\(_4\) were 560.0, 556.4, 588.6 and 469.3 mm, respectively as shown in Table 7. The effect of MTW on the growth was statistically significant as shown in the ANOVA Table 8 with calculated value of F (2.78) at P ≤ 5%.

The stem thickness (diameter) of the tomato plant measured twice during the vegetative growth indicated that the plant irrigated with MTW (water treated with magnetic flux densities 124, 319 and 719 G denoted as T\(_i\),

\[\delta = \sqrt{\frac{\sum (d - \bar{d})^2}{n - 1}}\]

\[\delta_{Er} = \frac{\delta}{\sqrt{n}}\]

\[t_{cal} = \frac{d}{\delta_{Er}}\]
T₁ and T₂) had bigger stem diameter than the tomato plant irrigated with NMTW (T₃ as control experiment). The mean stem diameters of tomato plant at 39 days after planting for T₁, T₂, T₃ and T₄ were 6.21, 6.43, 6.19 and 5.09 mm, respectively while the corresponding mean stem diameters at 49 days after planting were 8.64, 7.99, 8.21 and 6.96 mm as shown in Tables 9 and 10. The results of growth rate and stem thickness indicated that magnetically treated water also known as magnetic treatment of irrigation water or magnetized water had significant effect on growth of tomato plant. This increased in rate of growth of tomato plant in this study was in agreement with the work of Maheshwari and Grewal (2009) that magnetic treatment of irrigation water increased growth and yield of vegetable crop.

The mean yield of tomato for T₁, T₂, T₃ and T₄ were 127.44, 153.69, 149.39 and 91.10 g, respectively as shown in Table 11. The yield increment of MTW for T₁, T₂, T₃ over NMTW were 39.9, 68.7 and 64.0%, respectively.

### Table 1. Mean values of chemicals properties of soil after 45 days treated by magnetic water

| Water treated with magnetic flux density (G) | pH  | Cation (cmol/kg) | N (%) | Organic (%) | Acidic |
|--------------------------------------------|-----|----------------|-------|-------------|--------|
|                                            |     | Ca⁺⁺⁺           | Mg⁺⁺⁺ | K⁺⁺⁺        | Na⁺⁺⁺  |
| 719                                        | 6.23| 3.16            | 1.68  | 2.67        | 1.58   |
| 319                                        | 6.27| 2.87            | 1.55  | 2.47        | 1.66   |
| 124                                        | 6.23| 3.04            | 1.93  | 1.90        | 1.35   |
| NMTW                                       | 6.23| 2.82            | 1.72  | 2.35        | 1.42   |

OM = Organic matter, OC = Organic carbon, NMTW = Non magnetically treated water

### Table 2. ANOVA for the precipitation of some macro elements in the soil treated with magnetically treated and non-magnetically treated water.

| Parameter       | Degree of freedom | tcal at α = 0.05 (α/2 = 0.025) | Effect |
|------------------|-------------------|---------------------------------|--------|
| Calcium          | 2                 | 2.415                           | NS     |
| Potassium        | 2                 | 2.200                           | NS     |
| Nitrogen         | 2                 | 0.327                           | NS     |
| Organic matter   | 2                 | 1.764                           | NS     |
| Organic carbon   | 2                 | 1.904                           | NS     |

NS = Not Significant

### Table 3. Height of tomato plant 26 days after planting

| Row | Tomato plant height (mm) | T₁ | T₂ | T₃ | T₄ |
|-----|--------------------------|----|----|----|----|
| 1   | 160                      | 190| 200| 130|    |
| 2   | 170                      | 190| 130| 145|    |
| 3   | 170                      | 230| 230| 120|    |
| 4   | 140                      | 150| 220| 150|    |
| 5   | 140                      | 180| 155| 140|    |
| 6   | 160                      | 170| 190| 140|    |
| 7   | 140                      | 140| 270| 135|    |

Mean 154.3 178.6 199.3 137.1

T₁ = Water treated with 124 G, T₂ = Water treated with 319 G, T₃ = Water treated with 719 G and T₄ = NMTW

### Table 4. Height of tomato plant 32 days after planting

| Row | Tomato plant height (mm) | T₁ | T₂ | T₃ | T₄ |
|-----|--------------------------|----|----|----|----|
| 1   | 330                      | 320| 335| 240|    |
| 2   | 340                      | 360| 280| 260|    |
| 3   | 330                      | 385| 350| 210|    |
| 4   | 270                      | 330| 400| 270|    |
| 5   | 280                      | 330| 280| 240|    |
| 6   | 330                      | 310| 310| 260|    |
| 7   | 235                      | 240| 355| 225|    |

Mean 302.1 325.0 330.0 243.6

### Table 5. Height of tomato plant 37 days after planting

| Row | Tomato plant height (mm) | T₁ | T₂ | T₃ | T₄ |
|-----|--------------------------|----|----|----|----|
| 1   | 480                      | 470| 460| 350|    |
| 2   | 520                      | 535| 410| 330|    |
| 3   | 490                      | 500| 480| 310|    |
| 4   | 430                      | 445| 560| 390|    |
| 5   | 440                      | 460| 400| 350|    |
| 6   | 430                      | 430| 420| 370|    |
| 7   | 335                      | 335| 475| 320|    |

Mean 446.6 453.6 457.9 345.7

### Table 6. Height of tomato plant 41 days after planting

| Row | Tomato plant height (mm) | T₁ | T₂ | T₃ | T₄ |
|-----|--------------------------|----|----|----|----|
| 1   | 560                      | 560| 520| 430|    |
| 2   | 545                      | 560| 510| 450|    |
| 3   | 550                      | 555| 570| 335|    |
| 4   | 520                      | 510| 610| 440|    |
| 5   | 550                      | 535| 455| 420|    |
| 6   | 460                      | 520| 465| 400|    |
| 7   | 420                      | 490| 560| 380|    |

Mean 515.0 532.0 530.0 407.9

### Table 7. Height of tomato plant 47 days after planting

| Row | Tomato plant height (mm) | T₁ | T₂ | T₃ | T₄ |
|-----|--------------------------|----|----|----|----|
| 1   | 575                      | 570| 530| 510|    |
| 2   | 610                      | 560| 520| 480|    |
| 3   | 560                      | 565| 600| 410|    |
| 4   | 540                      | 560| 660| 445|    |
| 5   | 615                      | 570| 520| 500|    |
| 6   | 560                      | 520| 615| 430|    |
| 7   | 460                      | 550| 675| 510|    |

Mean 560.0 556.4 588.6 469.3
Chern, C. C. (2012) Application of magnetic water to stimulate the lady’s finger (Abelmoschus L.) moth plant growth. B. Eng. Thesis, University of Technology, Malaysia.

De Souza, A., Garcia, D., Sueiro, L., Liea, L. and Porras, E. (2005). Pre-sowing magnetic treatment of tomato seeds: effects on the growth and yield of plants cultivated late in season, Spanish Journal of Agricultural Research, 3 (1): 112-122.

Dhawi, F. (2014) Why magnetic fields are used to enhance a plant’s growth and productivity? Journal of Annual Research and Review in Biology 4 (6): 886 – 896.

Ejeiji, 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 Engr. 1 (1): 18-24.

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

Gabrielli, C., Jaouhari, R., Maurin, G. and Keddam, M. (2000). Magnetic water treatment for scale prevention, Elsevier Science, 35 (13): 3249–3259.

Gomez, K. A. and A. Gomez. 1984. Statistical Procedures for Agricultural Research, 2nd ed. New York: John Wiley and Sons.

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, 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 (Cicer arrietinum L.). Agriculture and Biology Journal of North America, 1 (4): 671-676.

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

Kronenberg, K. J. (1985). Experimental evidence for effects of magnetic fields on moving water. IEEE Trans. on Magnetics, 21 (5): 2059-2061.

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, Vol. 96 No 8 pp 1229-1236.

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

Mdsa’at S. K. (2006). Subsurface flow and free water surface flow constructed wetland with magnetic field for leachate treatment. M.Eng. Thesis submitted to Faculty of Civil Engineering, University of Technology, Malaysia.

Mohammed, A. I. (2013). Effects of magnetized low quality water on some soil properties and plant growth. International Journal of Research in Chemistry and Environment, 3 (2): 140 – 147.

Montgomery, D. C., Runger, G. C., Hubele, N. F (1998). Engineering statistics. John Wiley and Sons, Inc, NY: 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.

Noran, R., Shani, U and Lin, I. (1996) The effect of irrigation with magnetically treated water on the translocation of minerals in the soil. Magnetic and Electrical Separation, 7: 109-122.

Ogunlela, A.O (2001) Stochastic Analysis of Rainfall Events in Ilorin, Nigeria. Journal of Agricultural Research & Devt, 39 - 49.

Okoledo, J. O, Gathua, K. W. and Woomer, P. L (2002). Laboratory methods of soil and plant analysis: A working manual, the 2nd Edition. TSBF-CIAT and Sacred Africa, Nairobi Kenya: 29-90.

Podlesny, J., Pietruszewski, S. and Podolecna, A. (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. Int. Agrophysics, 18: 65-67.

4 CONCLUSION

Magnetically treated water increased the precipitations (concentrations) of calcium, potassium, sodium, nitrogen, phosphorus and organic carbon when water was treated with magnetic flux densities 124 and 719 G. Magnetically treated water increased the rate of tomato growth and stem thickness. Magnetically treated water had significant effect on the growth of tomato plant. The increased in precipitation (concentration) of the cations and anions enhanced plant growth and increased the yield of tomato by 39.9 to 68.7% in this study.

5 RECOMMENDATION

More research should be conducted on the effect of magnetically treated water on the precipitation of chemicals from the soil for plant growth using higher magnetic flux densities and on different soil types.

REFERENCES

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