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Original Article

Influence of Magnetized Water and Seed on Yield and Uptake of Heavy Metals of Tomato

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Abstract

This study assessed influence of magnetized water (MW) and magnetized seed (MS) on yield and uptake of heavy metals of tomato. Tomato seeds were put on permanent magnet (1000 gauss) for 24 hours and water was allowed to flow through magnetic flux density 319 gauss. Tomato seeds (variety UC82B) were planted in 16 pots, thinned after 21 days to one tomato/pot and irrigated with MW or non-magnetized water (NMW). Four treatments used were MS and MW (T_1), non-magnetized seed (NMS) and MW (T_2), MS and NMW (T_3), NMS and NMW (T_4). A 1.0 litre of water was applied to tomato plant in a completely randomized design and each treatment was replicated 4 times. Yields and concentrations of cadmium, copper, chromium, iron, manganese, nickel, lead and zinc were determined from the tomato fruit. The mean yields for T_1, T_2, T_3 and T_4 were 288.1, 275.8, 176.6 and 200.1 g/pot, respectively. Mean concentrations of Iron for T_1, T_2, T_3 and T_4 were 0.015, 0.010, 0.010 and 0.010 mg/L, respectively. Mean concentrations of zinc for T_1, T_2 T_3 and T_4 were 0.030, 0.110, 0.115 and 0.125 mg/L. The values of copper, iron, lead, manganese and zinc for T_2 were 0.02-0.03, 1.2-1.8, 0.03-0.07, 0.10-0.12 and 0.00-0.01 mg/L. The corresponding values for T_4 were 0.02-0.02, 1.30-1.60, 0.04-0.04, 0.08-0.11 mg/L but Zn was not detected. Concentrations of heavy metals in the tomato were below FAO/WHO permissible limits. MW and MS increased tomato yield and didn't increase uptake of heavy metals that could cause diseases to man.

Keywords: heavy metals in tomato; irrigation; magnetized water; pair t-test; tomato quality

Introduction

Magnetized water also called magnetically treated water or magnetic treatment of water is the water that has passed through magnetic field. It is a non-chemical method and environmentally-friendly that boosts crop yield (Maheshwari and Grewal, 2009; Babu, 2010; Yusuf and Ogunlela, 2017a). It also improves crop quality, increased minerals dissolvability of water for calcium, nitrogen, potassium, iron and lead which could enhance nutrients uptake of crops (Selim, 2008; Babu, 2010; Hozayn and Abdul-Qados, 2010). Magnetically treated water increased nutritional quality of tomato such as vitamin A, vitamin C and slightly increased uptake of lead content (Yusuf and Ogunlela, 2016). Yusuf and Ogunlela (2017b) pointed out that magnetic treatment of irrigation water (magnetized water) increased the rate of water absorption by plant for evapotranspiration which eventually increased the rate of vegetative growth of tomato plant, nutrient uptake and the yield. Rawabdeh *et al.* (2014) pointed out that magnetically treated water significantly increased essential elements such as nitrogen, phosphorus and potassium uptake and their translocation when compared with plants irrigated with tap water that was non magnetically treated water. Othman *et al.* (2009) also pointed out that magnetic treatment of landfill leachate improved the removal of suspended solid, chemical oxygen demand and biochemical oxygen demand by 60 to 80% using a magnetic field strength of 0.55 T (5,500 gauss).

Magnetically treated water enhanced uptake of potassium and phosphorous which are needed for the plant cell's chemical reactions that are essential for the formation and movement of carbohydrates, development of roots which are necessary for absorption of minerals, water and ATP (adenosine triposphate) which is a basic molecule of energy and nucleic acids (Yano *et al.*, 2004; Taia *et al.*, 2007). ELshokali and Abdelbagi (2014) also concluded that

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magnetized water improved the calcium, iron, potassium and zinc contents in seeds of onion, sunflower and tomato fruit which significantly increased the production quality of the plants compared to non-magnetized water.

Magnetized water has ability to stimulate defense system, produced photosynthetic activity, and increased translocation efficiency of photoassimilates in common bean plants (Moussa, 2011). The uptake of the some elements such as nitrogen, calcium, sulphur and phosphorus by crops irrigated with magnetized water could improve the nutritional quality (like protein and vitamin C contents).

A few heavy metals such as lead, copper, manganese, zinc, iron and chromium and nickel are essential for plant metabolism in trace amounts but they become toxic to plant and animal when they are available in excess and above WHO (World Health Organisation) permissible limits (Rawabdeh *et al.*, 2014). Magnetized water increased crop yield and enhanced nutrients uptake (Maheshwari and Grewal, 2009; Babu, 2010; Rawabdeh *et al.*, 2014) but if magnetized water increased uptake of heavy metals above the permissible limits, it could cause certain diseases such as cancer, neurological disorder, hypertension and gastrointestinal disorder to man. There is need to determine the effect of magnetized water on the uptake of heavy metals by some crops to prevent some diseases which could affect man due consumption of crops produced with magnetized water.

The north and south poles of the electromagnetic cores on the treatment pipe should be alternated for effective treatment of the irrigation water by the magnetic field as stated by (McMahon, 2006). Maheshwari and Grewal (2009) used magnetic flux density between 35 and 1360 gauss (G) which was measured inside the pipe. Podlesny *et al.* (2004) pointed out that the residence time for treatment of irrigation water in magnetic field should be 15 s while Aladjadjiyan (2007) indicated that 60 to 600 s was appropriate for effective magnetic treatment of water. The objective of this study was to determine the influence of magnetized water and magnetized seed on the yield and uptake of heavy metals from tomato fruit.

Materials and Methods

Location of the study

The study was carried out at the Research Farm of the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Kwara State, Nigeria between 23rd December, 2016 and 15th July, 2017. Ilorin lies on the latitude 8° 30′N and longitude 4° 35′E at an elevation of about 340 m above mean sea level (Ejieji and Adeniran, 2009). Ilorin is in 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 (Ogunlela, 2001). The experiment for this study to determine if magnetized water and magnetized seed could increase uptake of heave metals was conducted twice to have a reliable results.

Determination of crop evapotranspiration, water requirement 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 and volume of water required daily by tomato plant and volume of water required in three (3) days irrigation interval by the tomato plant were determined using Equations (1), (2), (3), (4), (5), (6), (7) and (8), respectively:

$$(1)\ ET_c = k_c \times ET_o$$

$$(2)\ AW = \frac{\rho_b}{\rho_w}\left(\frac{FC - WP}{100}\right)D_b$$

$$(3)\ WP = \frac{FC}{F}$$

$$(4)\ d_n = P_n \times AW$$

$$(5)\ I_v = \frac{d_n}{ET_c}$$

$$(6)\ V_d = C_c \times A_b \times ET_c$$

$$(7)\ V_i = C_c \times A_b \times ET_c \times I_v \times N_p$$

where ET_c is the crop evapotranspiration (mm/day), k_c is the crop coefficient, ET_o is the reference evapotranspiration (mm/day), D_F is the depth of water required to bring moisture content to FC at the beginning of the experiment (mm), ρ_b is the soil bulk density (g/cm^3), ρ_w is the density of water (g/cm^3), FC is the field capacity of the soil (%), Θ is the initial moisture content of the soil prior to irrigation (%), D_b is the depth of the bucket or pot (mm), Aw is the available water (mm), WP is the wilting point (%), I_v is the irrigation interval (day), d_n is the net depth of irrigation (mm), P_n is the percentage of available water supply during irrigation (fraction, 50% = 0.5), C_c is the crop canopy but taken as 100% (1), V_d is the volume of water required by tomato plant (litre/day), A_b is the area of the bucket (m^2), N_p is the number of plants that are to be irrigated and V_i is the volume of water required by plant per irrigation (litre).

F in equation (4) is a factor ranging from 2.0 - 2.4 depending on the percentage of silt in the soil (Sani, 2003). The value of F used was 2.2 and WP was calculated to be 12.26% when FC was 26.98%. The values of crop coefficient (k_c) used was 1.15 because Ufoegbune *et al.* (2012) indicated that k_c of tomato at flowering stage was 1.15. Reference evapotranspiration (ET_o) of Ilorin for the North Central zone from the graph by Chineke *et al.* (2011) for peak value during the month of March of the year is 5.5 mm/day and it was used in this study and A_b of the bucket (pot) was equal to 0.05433 m^2.

Chemical properties of soil used

The chemical properties of soil used in the study are presented in Table 1. Sample A was the chemical properties of soil used in the first experiment which was conducted between 23rd December, 2016 and 18th March, 2017 (85 days) in which the tomato yield was not considered in the study but concentrations of some heavy metals in the tomato fruit were determined. Sample B was the chemical properties of soil used in the second experiment that was conducted between 23rd March and 15th July, 2017, which lasted for 114 days. Tomato yield and concentrations of some selected heavy metals in the tomato fruit were determined in the second experiment.

Treatment of the water by magnetic field and chemical properties of water used

The water used in this study was fetched from University of Ilorin dam (at downstream, about 80 m away from the dam). The chemical properties of the water were presented in Table 2. The irrigation water was allowed to pass through a magnetic flux density of 319 gauss (31.9 mT) for about 113 s. The magnetic field was produced by electromagnet designed for treating the irrigation as shown in Figs. 1 and 2. The equivalent magnetic flux density between two magnetic cores without air gap was 1,684 gauss. The magnetic flux density was measured inside the rectangular treatment pipe in which 2 magnetic cores was 20 mm away from each other using a gaussmeter, Model GM-2 by Alpha Lab Inc. Water samples were taken from magnetized and non-magnetized water for chemicals analysis and the concentrations of some selected heavy metals were analyzed as shown in Table 2. A 1.0 litre of magnetized or non-magnetized water was carefully applied to the soil in each pot containing tomato plant at 3 days interval during the vegetative growth but the irrigation interval was reduced to 2 days during the flowering/fruiting stage of the tomato plant to avoid water stress which could affect the tomato yield. The electromagnetic treatment device was developed locally in Ilorin using readily available materials mainly 2.19 mm thick copper wire (gauge 15) and transformer from worn-out uninterrupted power supply (UPS) as the core after the supporting sides of it were cut off and the coils (primary and secondary coils) were also removed. A new winding of 180 turns was made on each of the twenty (20) lamination cores with the copper wire. The rectangular pipe was 20 by 50 mm (but internal dimension was 15 by 46 mm) and 3 m long constructed from a transparent perspex glass of thickness 2 mm.

Table 1. Chemical properties of the soil used

Element	Sample A	Sample B
pH	4.70	5.30
N (%)	0.80	1.00
P (mg/L)	0.39	0.22
K^{+} (mg/L)	0.11	0.13
Pb^{2+} (mg/L)	1.80	1.30
Zn^{2+} (mg/L)	0.90	0.80
Cr^{2+} (mg/L)	0.14	0.07
Cu^{2+} (mg/L)	0.54	0.55
Cd^{2+} (mg/L)	0.01	0.01
Fe^{2+} (mg/L)	8.50	8.70
Mn^{2+} (mg/L)	0.55	0.60

Table 2. Concentrations of some selected heavy metals in the water used for irrigation

Element	WHO limits (2003)	MTW	NMTW
Pb^{2+} (mg/L)	5.00	ND	ND
Zn^{2+} (mg/L)	2.00	ND	ND
Cr^{2+} (mg/L)	1.00	ND	ND
Cu^{2+} (mg/L)	0.20	ND	ND
Cd^{2+} (mg/L)	0.01	ND	ND
Fe^{2+} (mg/L)	5.00	ND	0.10
Mn^{2+} (mg/L)	0.26	ND	ND

WHO = World Health Organization, ND = Not detected
MW = Magnetized water, NMW = Non-magnetized water

Fig. 1. Electromagnetic treatment device

Fig. 2. Magnetized water from the electromagnet

Parameters analysed

Two samples of tomato were randomly harvested from T_1, T_2, T_3 and T_4 after 95 days (for the second experiment) but 85 days (for the first experiment) for the determination of concentrations of some selected heavy metals in the tomato.

Determination of concentrations of lead and other heavy metals

The tomato was ground (wet tomato paste) and sieved through 2 mm sieve. A 2 g of the sample was weighed and heated to dryness in a well-cleaned porcelain crucible between 450 and 500 $^{\circ}$C in a hot plate. The ash content was then dissolved in 5 ml HNO_3, HCL and H_2O in ratio of 1:2:3, respectively and this was heated on a hot plate until brown fume disappeared. A 5 ml of deionized water was added and heated until a colorless solution was obtained. The mineral solution was transferred into 100 ml volumetric flask and filtered through Whatman No 42 filter paper. This solution was then analyzed by Atomic Absorption Spectrophotometer (AAS) as given by AOAC (2000). The same procedure was used for digestion process and AAS was used to analyze other heavy metals as given by AOAC (2000).

Statistical analysis by Completely Randomized Design (CRD)

Statistical analysis on the yield of tomato was computed to determine if the influence of magnetized seed and magnetized water was statistically significant on the tomato yield or not using Completely Randomized Design (CRD). Sum of square treatment (SST_R), Sum of square total (SST_O) correction factor (C.F) and sum of square error (SS_E) were computed using Equations (9), (10), (11) and (12), respectively. The Analysis of Variance (ANOVA) was based on values generated from Equations (9), (10) and (12).

$$(8)\ SST_R = \frac{\sum T_i^2}{t} - C.F$$

$$(9)\ SST_O = \sum X_i^2 - C.F$$

$$(10)\ C.F = \frac{G^2}{N}$$

$$(11)\ SS_E = SST_O - SST_R$$

where T_i is the total yield of each treatment, t is the number of treatments used, X is the individual yield based on the treatment used, G is the total yield from all the treatments used and N is the number of observation which is equal to the product of number of treatments (t) and number replications (r) or (t x r).

Statistical analysis by pair t-test

A pair t-test statistical analysis was also computed between T_1 versus T_4 and T_2 versus T_4. The difference between the two mean of the results was determined and used to compute the standard deviation, standard error and t-test value using equations (13), (14a) or (14b), (15) and (16), respectively as given by Montgomery (1998). The calculated values of the t-test and that of table values were shown in Table 3.

$$(12)\ \bar{d} = \frac{\sum d}{n}$$

$$(13a)\ \delta = \sqrt{\frac{\sum \left(d - \bar{d}\right)^2}{n-1}}$$

$$(13b)\ \delta = \sqrt{\frac{\sum d^2 - n\left(\bar{d}\right)^2}{n-1}}$$

$$(14)\ \delta_{Er} = \frac{\delta}{\sqrt{n}}$$

$$(15)\ t_{cal} = \frac{\bar{d}}{\delta_{Er}}$$

where $\bar{d}$ is the mean of the difference from the data x_1 and x_2, Σd is the summation of d, n is the number of the treatments (observations), δ is the standard deviation, δ_{Er} is the standard error and t_{cal} is the calculated value of t which was compared with the table value of t_{Tab} at $\alpha = 5\%$ significant level but 2.5% ($\alpha = 0.05/2 = 0.025$) for paired t-test. For example, the tomato yield between T_2 and T_4 extracted from Table 4 for pair t-test was computed as follows for T_2 versus T_4.

Table 3. Data of tomato yield for computation of pair t-test

T_2 (NMS + MW)	T_4 (NMS + NMW)	d = T_1 - T_2	d^2
168.9	165.4	3.5	12.25
390.7	305.2	85.5	7,310.25
231.8	146.6	65.2	7,259.04
311.6	183.2	128.4	16,486.56
n = 4		**Σd = 302.6**	**Σd² = 31068.10**

$$\bar{d} = \frac{302.6}{4} = 75.65 \quad (12)$$

$$\delta = \sqrt{\frac{31068.10 - 4(75.65)^2}{4-1}} = 52.21 \quad (13b)$$

$$\delta_{Er} = \frac{52.21}{\sqrt{4}} = 26.10 \quad (14)$$

$$t_{cal} = \frac{75.65}{26.10} = 2.898 \quad (15)$$

Results and Discussion

Effect of magnetized water and magnetized seed on yield of tomato

The total and mean yields of tomato plant irrigated by magnetized seed and magnetized water (T_1), non-magnetized seed and magnetized water (T_2), magnetized seed and non-magnetized water (T_3), non-magnetized seed and non-magnetized water (T_4) were presented in Table 4. The mean yields of tomato for T_1, T_2, T_3 and T_4 were 288.1, 275.8, 176.6 and 200.1 g/pot, respectively. The interaction of magnetized seed and magnetized water produced the highest yield of tomato fruit which means that magnetic field had positive effect on the seed but magnetized water had more influence on the tomato yield than the magnetized seed. Interaction of non-magnetized seed and magnetized water produced higher yield than the interaction of non-magnetized seed and non-magnetized water.

The highest yield of tomato was obtained with the tomato plant irrigated with magnetized water and magnetized seed (T_1) and the yield were followed by non-magnetized seed and magnetized water (T_2). This was in agreement with the yield obtained by Ali (2004) that interaction of magnetized seed and magnetized water produced the highest yield. Generally, magnetized water and non-magnetized seed increased the tomato yield than the non-magnetized water and non-magnetized seed. This was also in agreement with the results obtained by Alderfasi *et al.* (2016) that magnetic treatment of irrigation water increased biomass and yield of wheat, Barley and triticale crops. The influence of T_1, T_2, T_3 and T_4 was not statistically significant on tomato yield because the calculated value of F was1.859 while the table value was 3.49 (1.859 < 3.49) as shown in ANOVA Table 5 for the CRD. In addition to that, statistical analysis on the tomato yield using pair t-test for T_1 versus T_4, and T_2 versus T_4, the calculated value of t-test were 1.091 and 2.898, respectively but table value of t-test at α = 5% (α = 0.05) but for pair t-test α = 2.5% (α = 0.025) and at 3 degree of freedom was 4.176 . This means that the influence of magnetized seed and water were not statistically significant on the yield of tomato in this study because calculated value of pair t-test 1.091 and 2.898 were less than the table value 4.176 though the technology (magnetic treatment of irrigation water) increased yield of tomato and a good technology for crops production (Maheshwari and Grewal, 2009; Babu, 2010; Moussa, 2011).

Table 4. Total and mean yields of tomato

Row	Total and mean yield of tomato (g/pot)			
	T_1	T_2	T_3	T_4
1	398.8	168.9	148.1*	165.4
2	201.2	390.7	217.1	305.2
3	355.0	231.8	179.3	146.6
4	197.4	311.6	161.7*	183.2
Total yield	**1152.4**	**1103.0**	**706.2**	**800.4**
Mean yield	**288.1**	**275.8**	**176.6**	**200.1**

* = tomato plant with one branch of the stem was broken by wind (storm) which affected the yield
T_1 = MS + MW (Magnetized Seed and Magnetized Water)
T_2 = NMS + MW (Non-Magnetized Seed and Magnetized Water)
T_3 = MS + NMW (Magnetized Seed and Non-Magnetized Water)
T_4 = NMS + NMW (Non-Magnetized Seed and Non-Magnetized Water)

Table 5. Analysis of variance (ANOVA) of the tomato yield using CRD

Source of error	Degree of freedom (D.F)	Sum of square (SS)	Mean square (MS)	Calculated F	Tabular F at P ≤ 5 %
Treatment	3	36,458.09	12,152.70	1.859^{NS}	3.49
Error	12	48,435.20	6535.17		
Total	15	114,435.29			

NS = Not significant

Influence of magnetized water and seed on uptake of heavy metals by tomato

Uptake of heavy metals by the tomato was assessed based on the concentration of heavy metals in the tomato fruit. In the first experiment conducted between 23rd December, 2016 and 18th March, 2017, the mean concentrations of cadmium, copper, chromium, iron II, lead, manganese and zinc for combination of non-magnetized seed and magnetized water at 100% and 80% of water requirement supplied versus corresponding concentrations of heavy metals for the combination of non-magnetized seed and non-magnetized water were presented in Table 6. The concentrations of heavy metals in the second experiment for the combinations of magnetized seed and magnetized water as T_1, non-magnetized seed and magnetized water as T_2, magnetized seed and non-magnetized water as T_3 and non-magnetized seed and non-magnetized water as T_4 were presented in Table 7.

In the first experiment with the results shown in Table 6, cadmium and chromium were not detected (negligible) but values of copper, iron, lead, manganese and zinc with MW for T_1 and T_2, the range were 0.02-0.03, 1.2-1.8, 0.03-0.07, 0.10-0.12 and 0.00-0.01 mg/L, respectively. The corresponding values for NMW were 0.02-0.02, 1.30-1.60, 0.04-0.04, 0.08-0.11 mg/L and Zn was not detected (negligible). In the second experiment in Table 7, the concentrations of Lead for T_1, T_2, T_3 and T_4 were 0.015, 0.010, 0.010 and 0.010 mg/L, respectively. The mean concentrations of zinc in the tomato for T_1, T_2, T_3 and T_4 were 0.030, 0.110, 0.115 and 0.125 mg/L, respectively. The mean concentrations of cadmium, copper, manganese and nickel in tomato T_1, T_2, T_3 and T_4 were not detected. The combination of magnetized seed and magnetized water slightly influenced or increased uptake of iron II in the two experiments by 11.1 to 33.3% when 100% of water requirement was supplied. This results obtained was in agreement with results obtained by Rawabdeh *et al.* (2014) that magnetically-treated water (magnetized water) increased nitrogen, phosphorous and potassium uptake and their translocation in plant. Mohammed and Ebead (2013) also concluded that magnetically-treated irrigation water increased available soil phosphorous in celery and snow pea. Similarly, magnetized water slightly increased uptake and concentration of Lead in tomato fruit as pointed out by Rawabdeh *et al.* (2014) and Yusuf and Ogunlela (2016) especially when irrigation water was supplied at 80% instead of 100% water requirement. The higher concentrations of some heavy metals in the tomato fruit irrigated with

Table 6. Concentrations of heavy metals in the tomato in the first experiment

Heavy metal	Magnetized water, mg/L		Non magnetized water, mg/L		WHO Limits (2003)	FAO Limits (1985)	Health implication on man according to SON Act 2007
	T_1	T_2	T_1	T_2			
Cadmium	ND	ND	ND	ND	0.01	0.01	Toxic to kidney
Copper	0.02	0.03	0.02	0.02	0.20	0.20	Gastrointestinal disorder
Chromium	ND	ND	ND	ND	1.00	1.00	Cancer
Iron II	1.80	1.20	1.60	1.30	5.00	5.00	None
Lead	0.03	0.07	0.04	0.04	5.00	5.00	Cancer, mental retardation in infant, toxic to central and peripheral nervous systems
Manganese	0.12	0.10	0.08	0.11	0.26	-	Neurological disorder
Nickel	ND	ND	ND	ND	1.00	0.20	Possible carcinogenic
Zinc	0.01	ND	ND	ND	2.00	2.00	None

T_1 = 100% of water requirement was supplied, T_2 = 80% of water requirement was supplied; ND = Not detected, SON = Standards Organization of Nigeria for Drinking Water Quality; FAO = Food and Agriculture Organization of the United Nations; WHO = World Health Organization

Table 7. Concentrations of heavy metals in the tomato in the second experiment

Heavy metal	Concentration of heavy metals in the tomato (mg/L)					
	T_1	T_2	T_3	T_4	WHO limits (2003)	FAO limits (1985)
Copper	ND	ND	ND	ND	0.20	0.20
	ND	ND	ND	ND		
Chromium	ND	ND	ND	ND	1.00	1.00
	ND	ND	ND	ND		
Iron II	0.010	0.010	0.010	0.010		
	0.020	0.010	0.010	0.010	5.00	5.00
Mean	**0.015**	**0.010**	**0.010**	**0.010**		
Manganese	ND	ND	ND	ND	0.26	-
	ND	ND	ND	ND		
Nickel	ND	ND	ND	ND	0.01	0.01
	ND	ND	ND	ND		
Lead	0.010	0.010	0.010	0.010		
	0.020	0.010	0.010	0.010	5.00	5.00
Mean	**0.015**	**0.010**	**0.010**	**0.010**		
Zinc	0.050	0.110	0.110	0.140		
	0.010	0.110	0.120	0.110	2.00	2.00
Mean	**0.030**	**0.110**	**0.115**	**0.125**		

ND = Not detected; T_1 = MS + MW (Magnetized Seed and Magnetized Water); T_2 = NMS + MW (Non-Magnetized Seed and Magnetized Water); T_3 = MS + NMW (Magnetized Seed and Non-Magnetized Water); T_4 = NMS + NMW (Non-Magnetized Seed and Non-Magnetized Water) magnetized water were in agreement with the results obtained by Babu (2010) that magnetically-treated water increased dissolvability of water for plant minerals and increased nutrients uptake by plant. Concentrations of the heavy metals in the tomato fruits with T_1, T_2, T_3 and T_4 were below (FAO/WHO) permissible limits and could not cause any disease to man. Magnetized water increased tomato yield and did not add heavy metals to tomato fruit.

Conclusions

Combination of magnetized seed and magnetized water increased tomato yield by 44% while combination of non-magnetized seed and magnetized water increased tomato yield by 27%. Magnetized water had more influence on tomato yield than just magnetized the seed and irrigated with non-magnetized water. Magnetized water did not add heavy metals to the tomato which could be harmful to man and all the concentrations of heavy metals in the tomato were below FAO/WHO permissible limits. Magnetic treatment of irrigation water (magnetized water) is a non chemical method and environmentally-friendly that boosts crop yield should be adopted and use for crop production in Nigeria and other countries. More research should be conducted on the uptake of heavy metals by crops irrigated with magnetized water in areas having high concentration of heavy metals to know the effect of magnetized water and seed on uptake of heavy metals.

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