Effect of magnetized water on water use efficiency, yield and nutritional qualities of watermelon under deficit irrigation

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Abstract: Magnetized water (MW) is a non-chemical method and new technology for crop production. It is environmentally-friendly which improves water use efficiency (WUE) and enhances high crop yield. This study was conducted to determine the effect of MW on WUE, yield and nutritional qualities of watermelon under irrigation deficiency in a garden shed. A completely randomized design was used for the experimental layout. Irrigation water was treated using magnetic flux density of 319 Gauss. Water applied as the treatments were 100%, 80%, 60% and 50% water requirement and each treatment was replicated four times. Watermelon seed (variety: Kaolack with LOT number: VG-PV-0519-KA) was planted in 15 litres pot^{-1} (285 mm diameter and 255 mm depth) with 16 pots for MW and 16 pots for non-magnetized water (NMW). The mean yield of watermelon irrigated with 100%, 80%, 60% and 50% MW were 7.59, 5.38, 5.12 and 2.11 kg pot^{-1}, respectively, while the corresponding values for NMW were 6.28, 3.92, 2.72 and 1.76 kg pot^{-1}. Values water WUE of watermelon irrigated with MW were 175.69, 155.49, 197.68 and 97.69 kg pot^{-1} m^{-3} and the corresponding values for NMW were 154.37, 113.29, 112.74 and 61.48 kg pot^{-1} m^{-3}. Percentage contents of water, carbohydrate, crude protein, ash, crude fibre, fat and oil in the watermelon irrigated by MW were 90.87%, 4.45%, 2.67%, 0.54%, 0.22% and 1.265%, respectively, while the corresponding values for NMW were 91.35%, 4.15%, 2.61%, 0.47%, 0.20% and 1.22%. Effect of MW was statistically significant on yield and WUE. MW is recommended for growing watermelon because it boosts watermelon yield and increases WUE.

Keywords: irrigation, magnetized water, water use efficiency, watermelon, paired t-test

Citation: Yusuf, K. O., T. R. Ogunbamowo, and R. O. Obalowu. 2020. Effect of magnetized water on water use efficiency, yield and nutritional qualities of watermelon under deficit irrigation. Agricultural Engineering International: CIGR Journal, 22(3): 51-60.

1 Introduction

Watermelon (*Citrullus lanatus*) is a berry fruit crop which belongs to the family of *Cucurbitacea* and has a growing period of 80 - 110 days. It is a vine-like flowering plant that grows and matures within three to four months. Watermelon fruit contains high water content (93%), little quantities of protein, fat, minerals and vitamins (Namdari et al., 2011). It contains Vitamin C which is essential for protecting man against dry skin, eczema, psoriasis, and Vitamin A that is needed for vision, prevents night blindness and reduces eye problems (Bendich and Olson, 1989). Watermelon is a tropical and sub-tropical plant which grows well in areas with temperatures higher than 25°C. In Nigeria, watermelons grow well both in the rain forest regions and in the dry savannah regions. Foliar diseases are common and more

Received date: 2019-06-23 **Accepted date:** 2019-10-25

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destructive in the forest zones and less destructive in dry savanna zones. This means that watermelon requires a warm climate and commonly grown in the northern part of Nigeria (savanna zone) but is rarely grown in the southern part of Nigeria (forest zone). The yield of watermelon in the southern part of Nigeria is normally characterized with low yield probably due to the unfavorable conditions and diseases. There is need to increase the production and technology to boost the yield of watermelon in the country, especially in the southern part of Nigeria. Irrigation water quality could be a factor affecting the low yield of watermelon.

Magnetized water (magnetically-treated water) is a simple method for treating irrigation water in order to modify the water structure, reduce the surface tension of water and increase solubility of water for minerals and enhanced high crop yield (Babu, 2010; Hozayn and Abdul-Qados, 2010; Moussa, 2011; Alderfasi et al., 2016). Babu (2010) indicated that that magnetic field modified water structure to be more cluster together and increased the absorption of magnetized water from the soil by plant than non-magnetized water. Yusuf and Ogunlela (2016) also reported that magnetized water increased nutritional qualities of tomato such as Vitamin A, Vitamin C and slightly increased the uptake of lead (Pb^{2+}) contents in the tomato fruit.

Moussa (2011) stated that magnetically treated water had the ability to boost the immunity of plant against some diseases, increased the photosynthetic activity and increased the translocation efficiency of photo assimilates in common bean plants. Therefore, the use of magnetized water for irrigating watermelon crop to boost the immunity against diseases could encourage and enhance the production of qualified watermelon in the southern parts of Nigeria and other tropical regions that have similar characteristics with the southern part of Nigeria. Most Nigerian farmers are not awared that watermelon could be grown in the pot (bucket) at home or in the garden shed to increase the availability of watermelon in the country which is good for human health.

Water is one the major factors that are essential for crop production, and water is normally very scarce during the dry season for irrigation both in the southern and northern parts of Nigeria. There is always high demand for water for domestic uses during dry season and this usually creates the competition for need for irrigation and domestic uses based on little available water sources (streams and rivers). Therefore, crops experience water deficiency during dry season, which affects the evapotranspiration requirement of the plant, uptake of plant nutrients, photosynthesis and crop yield. Anand et al. (2012) reported that magnetized water could alleviate the adverse effects of water stress (deficit irrigation) in crop because it reduced free radicals production and antioxidant enzyme activity. Magnetized water also increases the evapotranspiration rate and water use efficiency, thereby, accelerates the growth rate and boosts crop yield (Yusuf and Ogunlela, 2017a). This means that crop irrigated with magnetized water could withstand deficit irrigation, utilize the little quantity of water available in the soil for growth, and be resistance to some diseases.

Magnetic field strength ranging from 35 to 136 mT inside the pipe or hose is adequate for treating irrigation water (Maheshwari and Grewal, 2009). Othman et al. (2009) reported 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 550 mT. The water should stay in the magnetic field for at least 15 s (Podlesny et al., 2004), but Aladjadjiyan (2007) stated that 60 to 600 s were effective for the treatment of irrigation water by magnetic field. The objectives of this study were to determine the effect of magnetized water, on the water use efficiency, yield and nutritional qualities of watermelon under water deficit conditions.

2 Materials and methods

2.1 Location of the study

The research work was conducted at the Demonstration Farm of Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Kwara State, Nigeria. University is located in Ilorin South Local Government Area of Ilorin city. Ilorin lies on latitude 8°29'20.9"N and longitude 4°33'11.1"E and at an altitude of 290 m above mean sea level (Mijinyawa and Akpenpuun, 2015). The state is bounded by River Niger along its northern and eastern boundaries and shares a common boundary with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international boundary with the Republic of Benin in the west. The soils of Ilorin are loamy and clay. The climate of Ilorin is tropical with annual rainfall of about 1500 mm, the average maximum temperature of 38°C, average relative humidity of 77.50% and 7.1 h of sunshine daily (Olanrewaju, 2009). The minimum and maximum of temperatures of the study area in the Ilorin between May and September, 2014 were 16.5 and 41°C (Yusuf and Ogunlela, 2017a). The rainy season begins at about the end of March and lasts until early September, while the dry season begins in early October and ends in early March. This attribution predisposes the people to make farming their major occupation (Mijinyawa and Akpenpuun, 2015). The map of Nigeria and map of Kwara State where Ilorin South Local Government Area is located are shown respectively in Figures 1 and 2.

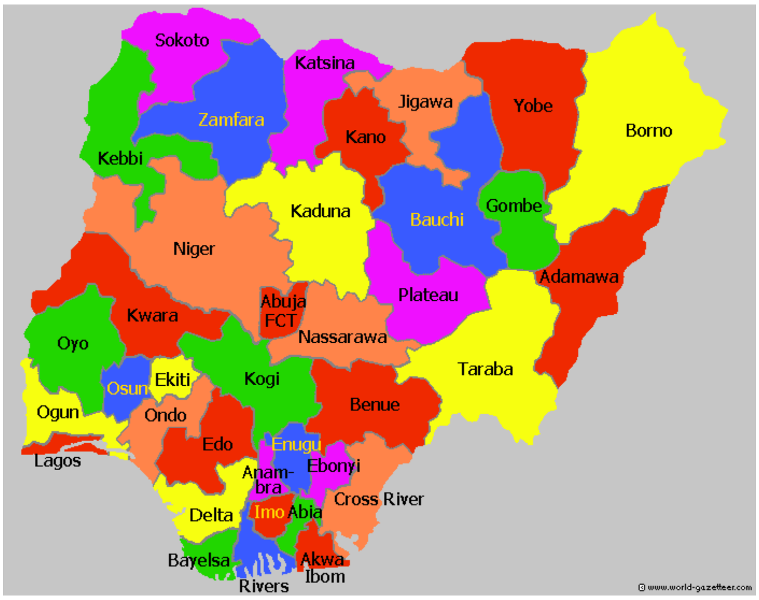

Figure 1 Map of Nigeria

Source: Minjiyawa and Akpenpuun (2015)

Figure 2 Map of Kwara State in which Ilorin is indicated

Source: Mijiyawa and Akpenpuun (2015)

2.2 Determination of reference evapotranspiration and crop evapotranspiration

Water requirement of the tomato plant is the total quantity of water that is needed to meet the required evapotranspiration by the plant. Reference evapotranspiration, which depends only weather conditions of a location was determined CROPWAT 8.0 which is based on FAO-56 Penman-Monteith (FAO-56 PM) formula given in Equation 1 while crop evapotranspiration of upland rice was determined using Equation 2 (Michael, 2008). Volume of water required daily by the watermelon per pot was determined using Equation 3.

$$ET_O = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.3U_2)} \quad (1)$$

Where ET_o is the reference evapotranspiration (mm day^{-1}), R_n is the net radiation at the crop surface (MJ m^{-2} day^{-1}), G is the soil heat flux density (MJ m^{-2} day^{-1}), T is the mean daily temperature at 2 m height (^{o}C), U_2 is the wind speed at 2 m above ground surface (m s^{-1}), Δ is the slope of vapour pressure (kPa ^{o}C^{-1}), e_s is the saturation vapour pressure (kPa), e_a is the actual vapour pressure (kPa) and $e_s - e_a$ is the saturation vapour pressure deficit (kPa).

$$ET_c = k_c \times ET_o \quad (2)$$

$$V_d = k_c \times ET_c \times A \quad (3)$$

Where ET_c is the crop evapotranspiration (mm day^{-1}), k_c is the coefficient of the crop (upland rice), ET_o is the reference evapotranspiration (mm day^{-1}), V_d is the volume of required and A is the area of the farm to be irrigated (m^2).

The mean reference evapotranspiration of Ilorin for a decade (2007 – 2016) using CROPWAT 8.0 was 5.68 mm day^{-1} for February and 6.14 mm day^{-1} for March. The peak value of ET_o was used for computing the water requirement of the rice to avoid water stress (water deficit), which could affect the yield of the watermelon. The crop evapotranspiration of watermelon was determined as given in the following expression using Equation 2 when k_c of watermelon at flowering stage ranges from 1.05 - 1.30 but 1.15 was used in this study. The volume of water required daily by the watermelon per pot was determined from Equation 3. Diameter of buckets used were 285 mm and 255 mm in depth given area of 0.0638 m^2.

$$ET_c = 1.15 \times 6.14 = 7.061 = 7.1 \text{ mm day}^{-1}$$

$V_d = 0.0071 \times 0.0638 = 0.00045298$ m^3 day^{-1} = 0.45298 litres day^{-1}, but = 1.812 liters for 4 days. Therefore, volumes of water required per pot during at 100%, 80%, 60% and 50% were 1.80, 1.4, 1.1 and 0.9 liter, respectively.

2.3 Determination of water requirement of soil and irrigation interval

The depth of water required to bring the soil to field capacity at the beginning of the experiment (D_F), available water (AW), wilting point (WP), net depth of irrigation (d_n) and irrigation interval (I_v), volume of water required to bring the moisture content to field at the beginning of irrigation (V_F) and volume of water required to bring the soil to its field capacity based on the net depth of irrigation in subsequent irrigation (V_b) were determined using Equations 4-10, respectively as given by Michael (2008) and Schwab et al. (1993).

$$D_F = \frac{\rho_b}{\rho_w}\left(\frac{FC - \theta}{100}\right) D_b \quad (4)$$

$$AW = \frac{\rho_b}{\rho_w}\left(\frac{FC - WP}{100}\right) D_b \quad (5)$$

$$WP = \frac{FC}{F} \quad (6)$$

$$d_n = P_n \times AW \quad (7)$$

$$I_v = \frac{d_n}{ET_c} \quad (8)$$

$$V_F = D_F \times A_F \quad (9)$$

$$V_n = d_n \times A_b \quad (10)$$

Where ρ_b is the soil bulk density (g cm^{-3}), ρ_w is the density of water (g cm^{-3}), D_b is the root zone or root depth of rice, P_n is the percentage allowable of available water (AW) to deplete before irrigation and A_F is the area of the bucket or pot (m^2).

F in Equation 6 is a soil factor ranging from 2.0 - 2.4 depending on the percentage of silt in the soil (Sani, 2003) and 2.2 was used in this study. WP was 13.26% when FC from previous study was 29.18% from Equation 6. Bulk density of soil was 1.4 g cm^{-3} for loamy sand, density of water is 1.0 g cm^{-3}, the initial moisture content of soil at the beginning of the experiment was 5.23% and irrigation was done when percentage of available water (P_n) was depleted to 50%. Available water, net depth of irrigation and irrigation interval were determined to 56.39 mm, 28.18 mm and 4 days, respectively.

2.4 Treatment of irrigation water by magnetic field, chemical composition of the irrigation water and soil used

The water used for irrigation in this study was obtained at the downstream of the end of University of Ilorin dam (about 50 m away from the dam). The irrigation water was allowed to pass through a magnetic flux density of 31.9 mT for about 113 s in this study. The magnetic field produced from the electromagnet which was designed and constructed for treating the irrigation as shown in Figures 3 and 4.

Figure 3 Electromagnetic treatment system with a fan for cooling the system

Figure 4 Collection of magnetized water from the electromagnet

The magnetic flux density was measured inside the rectangular plastic pipe using a Gaussmeter, Model GM-2 by Alpha Lab Inc. The chemical composition of the water before and after magnetization is presented in Table 1 while some of the chemical properties soil is presented in Table 2.

Table 1 Chemical properties of soil used

Element	Value
pH	6.3
N (%)	0.77
P (mg kg^{-1})	2.11
K^+ (cmol kg^{-1})	2.47
Na^+ (cmol kg^{-1})	1.66
Ca^{2+} (cmol kg^{-1})	2.87
Mg^{2+} (cmol kg^{-1})	1.55
Organic matter (%)	2.32
Organic carbon (%)	1.34

Table 2 Chemical composition of magnetized water and non-magnetized water

Element	MW	NMW
pH	7.5	7.4
N (NO3) (%)	43.0	42.7
P (mg L^{-1})	0.7	0.7
SO_4^{2-} (mg L^{-1})	49.1	47.8
K^+ (mg L^{-1})	0.9	0.9
Na^+ (mg L^{-1})	80.9	81.9
Ca^{2+} (mg L^{-1})	3.2	3.1
Mg^{2+} (mg L^{-1})	1.4	1.3
Electrical conductivity (μS cm^{-1})	182.5	186.0
Viscosity (N s m^{-2})	1.73 x 10^{-3}	1.82 x 10^{-3}

Note: MW = Magnetized water, NMW = Non-magnetized water

2.5 Determination of water use efficiency

Water use efficiency (WUE) is the ability of crop to convert water applied during irrigation into biomass or to convert the water applied into grain/fruit. WUE was determined using Equation 11 given by Khila et al. (2013). A 1.8 litre of water was applied to watermelon per pot per irrigation at 100% and irrigation was done 24 times for each treatment giving a total of 43.2 liters (0.0432 m^3) of water which was used for the entire growing season. Total water used 80, 60% and 50% were 0.0346, 0.0259 and 0.0216 m^3 pot^{-1}, respectively, and mean yields/pot at 100%, 80%, 60% and 50% of water applied during the irrigation for magnetized water were 7.59, 5.38, 5.12 and 2.11 kg pot^{-1}, respectively and the corresponding yields for non-magnetized water were 6.28, 3.92, 2.72 and 1.76 kg pot^{-1}. These values used for computing WUE

$$WUE = \frac{Y_d}{V_w} \times 100 \tag{11}$$

Where Y_d is the yield of crop/bucket (kg) and V_w is the volume of water applied (m^3) for the entire growing season per pot in this study.

$WUE = \frac{7.59}{0.0432} = 175.69$ kg pot^{-1} m^{-3} for magnetized water at 100% and the method was used for the computation of other WUE.

2.6 Parameters assessed from the watermelon

The yield of watermelon, water use efficiency and the nutritional qualities mainly the carbohydrate, crude protein, fat and oil, water content, ash/mineral and crude fibre contents were determined from the watermelon fruit. The yield of the watermelon was determined by weighing method and WUE was determined using Equation 11. The carbohydrate, crude protein, fat and oil, water content, ash/mineral and crude fibre contents were determined from the watermelon fruit using the standard method of Association of Official Analytical Chemists (AOAC) (2000).

2.7 Statistical analysis of tomato yield by completely randomized design (CRD) and pair t-test

2.7.1 Statistical analysis by CRD

Statistical analysis was determined to know if the effect of water deficit (water stress) was statistically significant on the yield of watermelon irrigated with magnetized water or non-magnetized water using 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 12-15, respectively. The analysis of variance (ANOVA) was based on values obtained from Equations 12, 13 and 15.

$$SST_R = \frac{\sum T_i^2}{t} - C.F \quad (12)$$

$$SST_O = \sum X_i^2 - C.F \quad (13)$$

$$C.F = \frac{G^2}{N} \quad (14)$$

$$SS_E = SST_O - SST_R \quad (15)$$

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

2.7.2 Statistical analysis by pair t-test

A pair t-test statistical analysis was also computed between magnetized water and non-magnetized water. 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 16-19, respectively as given by Montgomery et al. (1998). The calculated values of the t-test and that of table values were shown in Tables 3 and 4.

$$\bar{d} = \frac{\sum d}{n} \quad (16)$$

$$\delta = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n-1}} \quad (17)$$

$$\delta_{Er} = \frac{\delta}{\sqrt{n}} \quad (18)$$

$$t_{cal} = \frac{\bar{d}}{\delta_{Er}} \quad (19)$$

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 α = 5% significant level but 2.5% (α = 0.05/2 = 0.025) for paired t-test.

Table 3 Data of watermelon yield per treatment used for computation of paired t-test

MW (X_1)	NMW (X_2)	$d = X_1 - X_2$	d^2
30.35	25.13	5.22	27.25
21.50	15.69	5.81	33.76
20.47	10.86	9.61	92.35
8.43	7.04	1.39	1.93
n = 4		∑d = 22.03	$\sum d^2$ = 155.29

$$\bar{d} = \frac{22.03}{4} = 5.51$$

$$\delta = \sqrt{\frac{155.29 - 4(5.51)^2}{4-1}} = 3.36$$

$$\delta_{Er} = \frac{3.36}{\sqrt{4}} = 1.68$$

$t_{cal} = \frac{5.51}{1.68} = 3.280$ But table value of t-test = 3.182

Table 4 Data of water use efficiency for computation of paired t-test

MW (X_1)	NMW (X_2)	$d = X_1 - X_2$	d^2
175.69	154.37	21.32	454.54

155.49	113.29	42.20	1,780.84
197.68	112.74	84.94	7,214.80
97.69	61.48	36.21	1,311.16
n = 4		∑d = 184.72	$\sum d^2$ = 10,761.34

$$\bar{d} = \frac{184.72}{4} = 46.18$$

$$\delta = \sqrt{\frac{10,761.34 - 4(46.18)^2}{4-1}} = 27.27$$

$$\delta_{Er} = \frac{27.27}{\sqrt{4}} = 13.635$$

$t_{cal} = \frac{46.18}{13.635} = 3.387$ But, the table value of t-test = 3.182

3 Results and discussion

3.1 Effect of magnetized water on yield, water use efficiency and nutritional qualities of watermelon

From the study conducted on watermelon grown in pots in a garden shed (greenhouse), the total yields per treatments, the mean yields per pot (bucket) and water use efficiency of watermelon produced using magnetized water and non-magnetized water under water deficit conditions were presented in Table 5 and the ANOVA were shown in Tables 6. The nutritional qualities of watermelon were presented in Table 8. The total yield of watermelon per treatment with 4 replications for magnetized water at 100%, 80%, 60% and 50% water applied were 30.35, 21.50, 20.47 and 8.43 kg, respectively, but the corresponding values for non-magnetized water were 25.13, 15.69, 10.86 and 7.04 kg. The mean yield of watermelon with magnetized water at 100%, 80%, 60% and 50% were 7.59, 5.38, 5.12 and 2.11 kg pot^{-1}, respectively, while the yields for non-magnetized water were 6.28, 3.92, 2.72 and 1.76 kg pot^{-1} as presented in Table 5. Values of WUE by the watermelon irrigated with MW were 175.69, 155.49, 197.68 and 97.69 kg pot^{-1} m^{-3} and the corresponding values for NMW were 154.37, 113.29, 112.74 and 61.48 kg pot^{-1} m^{-3}. MW gave higher nutritional value which means that magnetic treatment of irrigation had a positive effect on the nutritional qualities of watermelon. The percentage contents of moisture content, carbohydrate, crude protein, ash, crude fibre, fat and oil in the watermelon irrigated by MW at 100% water application were 90.87%, 4.45%, 2.67%, 0.54%, 0.22% and 1.265%, respectively, while the corresponding values for NMW at 100% water application were 91.35%, 4.15%, 2.61%, 0.47%, 0.20% and 1.22% as presented in Table 8. This means that MW had a positive effect on the nutritional qualities of watermelon

Magnetized water produced higher yields of watermelon under the same deficit irrigation than the non-magnetized water as shown in Figure 5. This means that magnetic field had a positive effect on both seed and water. Magnetized water had more influences on the yield of tomato than the yield from magnetized seed only. Interaction between non-magnetized seed and magnetized water gave higher yield than the interaction of non-magnetized seed and non-magnetized water. The highest yield obtained with magnetized water was in agreement with the results obtained by Alderfasi et al. (2016) that magnetic treatment of irrigation water increased biomass and yield of wheat, and barley crops. MW also increased water use efficiency of watermelon. The values of WUE of watermelon irrigated with MW were 175.69, 155.49, 197.68 and 97.69 kg pot^{-1} m^{-3} and the corresponding values for NMW were 154.37, 113.29, 112.74 and 61.48 kg pot^{-1} m^{-3} as shown in Table 5. Babu (2010) reported that MW was easily absorbed by plant than the NMW in which the values, magnetic treatment of irrigation water enhanced high yield of tomato and was a good technology for crop production (Babu, 2010; Moussa, 2011; Yusuf and Ogunlela, 2017b). MW increased yield of watermelon because plant irrigated with magnetized water easily absorbed water for evapotranspiration with high nutrients for plant growth. This was in agreement with the conclusion by Yusuf and Ogunlela (2017a) that magnetic treatment of irrigation water increased the rate of water absorption by the plant for evapotranspiration by 1.25 to 1.35 mm day^{-1} of tomato which increased the rate of vegetative growth of the tomato plant. The magnetized water increased the nutritional values of watermelon and this was in agreement with the study of Yusuf et al. (2017c) that magnetically treated water increased the uptake of plant nutrients by the tomato plant which enhanced high crop yield, improved the nutritional qualities of tomato fruit but did not add heavy metals to the tomato.

Effect of water stress or deficit irrigation statistically significant at P values ≤ 5% for both on yield of watermelon for watermelon irrigated with MW and NMW. The calculated value of F was higher than the values of F for both MW and NMW as shown in Tables 6 and 7. This means that MW had a significant effect on the yield of watermelon when compared with the water yield from using NMW. This was in agreement with a study by Mohammed and Ebead (2013) that magnetized water could alleviate adverse effect of water stress on crop because it reduced free radicals production and antioxidant enzyme activity. Aoda and Fattah (2011) also reported that MW had a positive effect on the yield of maize when grown under water deficit conditions. Statistical analysis by the paired t-test revealed that MW had an effect on the yield of watermelon and statistically significant because the calculated value of t-test was 3.280 while the table value of t-test was 3.182 at α = 5% but α = 2.5% of paired t-test at 3 degrees of freedom. This means that the influence of magnetized water was statistically significant on the yield of watermelon in this study because the calculated value of pair t-test of 3.280 was greater than the table value 3.182. Magnetic treatment of irrigation (magnetized water) also had effects on the water use efficiency with a calculated value of t-test was 3.387 greater than the table value of t-test of 3.182 at α = 5%, but α = 2.5% of pair t-test at 3 degrees of freedom given by Montgomery (1998).

Table 5 Mean yield and water use efficiency of watermelon

Row	Yield (kg) with magnetized water				Yield (kg) with non-magnetized water			
	100% (V_{100})	80% (V_{80})	60% (V_{60})	50% (V_{50})	100% (V_{100})	80% (V_{80})	60% (V_{60})	50% (V_{50})
1	9.00	5.60	4.85	3.47	5.28	2.51	4.08	1.41
2	6.14	5.81	6.54	2.72	7.71	2.59	3.58	1.61
3	6.34	5.10	4.49	0.99	4.77	4.54	1.63	2.28
4	8.87	4.99	4.59	1.25	7.37	6.06	1.57	1.78
Total yield	30.35	21.50	20.47	8.43	25.13	15.69	10.86	7.04
Mean yield/pot	7.59	5.38	5.12	2.11	6.28	3.92	2.72	1.76
WUE (kg pot^{-1} m^{-3})	175.69	155.49	197.68	97.69	154.37	113.29	112.74	61.48

Note: 100% = Treatment in which full water requirement was supplied, WUE = Water use efficiency, V_{100} = 0.0432 m^3 of water was used for irrigation, V_{80} = 0.0346, V_{60} = 0.0259, V_{60} = 0.0216 m^3.

Table 6 ANOVA for the effect of deficit irrigation on the yield of watermelon using magnetized water

Source of variation	Degree of freedom	Sum of square	Mean square	Calculated value of F	Table value of F at p ≤ 5%
Treatment	3	60.830	20.277	16.512^{SN}	3.490
Error	12	14.733	1.228		
Total	15	75.563	5.038		

Note: SN = Significant at p ≤ 5%

Table 7 ANOVA for the effect of deficit irrigation on the yield of watermelon using non-magnetized water

Source of variation	Degree of freedom	Sum of square	Mean square	Calculated value of F	Table value of F at p ≤ 5%
Treatment	3	45.797	15.266	8.738^{SN}	3.490
Error	12	20.969	1.747		
Total	15	66.766	4.451		

Note: SN = Significant at p ≤ 5%

Table 8 Mean nutritional qualities of watermelon irrigated with MW and NMW

Treatments	Composition (%)					
	Moisture content	Carbohydrate content	Crude protein content	Ash/ Mineral content	Crude fibre content	Fat and oil content
MW	90.87	4.45	2.67	0.54	0.22	1.26
NMW	91.35	4.16	2.61	0.47	0.20	1.22

Note: MW = Magnetized water, NMW = Non-magnetized water

Figure 5 Watermelon irrigated with MW (left) and watermelon irrigated with NMW (right)

4 Conclusion

Magnetic treatment of irrigation water, also called magnetized water increased water use efficiency and increased the yield of watermelon. MW also improved the nutritional qualities of the watermelon by increasing the percentage contents of moisture content, carbohydrate, crude protein, ash, crude fibre, fat and oil in the watermelon when compared with watermelon irrigated by the NMW. The effect of magnetized water was statistically significant on the water use efficiency and yield of watermelon. Magnetic treatment of irrigation water is a non-chemical method and environmentally-friendly that boosts crop yield. The technology should be adopted and used for crop production in Nigeria for sufficient availability of watermelon and other crops in the country.

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