**LAUTECH Journal of Civil and Environmental Studies**
**Volume 6, Issue 2**
**DOI: 10.36108/laujoces/1202.60.0230**

# Evaluation of some selected soil properties of a drip irrigated tomato field at different moisture regimes in South-Western Nigeria

[1]Ogundipe, E.O., [1]Oniya, O.O., [1]Abegunrin, T.P. and [2]Awe, G.O.

[1] Department of Agricultural Engineering, Faculty of Engineering and Technology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
[2] Department of Crop, Soil and Environmental Sciences, Faculty of Agricultural Sciences, Ekiti State University, Ado Ekiti, Nigeria.

* Corresponding Author: E-mail oooniya@lautech.edu.ng; Tel: +2348062119857

*Submitted on: 02/02/2021* *Accepted on: 08/04/2021*

## Abstract
*Soil properties are important to the development of agricultural crops. This study determined some selected soil properties of a drip irrigated tomato (Lycopersicon esculentum M.) field at different moisture regime in South-Western Nigeria. The experiment was carried out using Randomized Complete Block Design with frequency and depth of irrigation application as the main plot and sub-plot, respectively in three replicates. Three frequencies (7, 5 and 3 days) and three depths equivalent to 100, 75 and 50% of water requirement were used. Undisturbed and disturbed soil samples were collected from 0-5, 5-10, 10-20 and 20-30 cm soil layers for the determination of some soil properties (soil texture, organic matter content, bulk density, infiltration rate and saturated hydraulic conductivity) were determined using standard formulae. Soil Water Content (SWC) monitoring was conducted every two days using a gravimetric technique. The soil texture was sandy loam for all the soil depths; average value of soil organic matter was highest (1.8%) in the 0-5 cm surface layer and decreased with soil depth; the soil bulk density value before and after irrigation experiment ranged from 1.48 and 1.73 g/cm$^3$ and 1.5 and 1.76 g/cm$^3$, respectively; there was a rapid reduction in the initial infiltration and final infiltration rate. Saturated hydraulic conductivity show similar trend although the 20-30 cm layer had the lowest value (50.84 mm/h); the SWC affect bulk density during the growing season. The study showed that soil properties especially bulk density and organic matter content affect irrigation water movement at different depth.*

**Keywords**: Soil properties; Drip irrigation; Moisture regime; Depth; Tomato.

## Introduction
Soil properties are very important to the development of agricultural crops; they influence crop outputs per unit plant. Organic matter contributes to improvement in soil physical properties; it stabilizes soil structure, thereby reducing soil bulk density (BD) and increasing total porosity (Pt) as well as hydraulic conductivity; influences soil aggregation status and aggregate stability (Obi and Ebo, 1995; Nnabude *et al.*, 2000; Nnabude and Mbagwu, 2001). Ikpe and Powell (2002) and Ewulo *et al.* (2008) found that low soil BD enhanced access to soil moisture and increased nutrient uptake which result in higher crop yield. According to Adekiya and Ojeniyi (2002), an increase in soil BD results in reduced uptake of N, P, K, Ca and Mg by tomato plant in alfisols of South-Western Nigeria. Thus a high soil BD has negative effects on the growth and yield of tomato because variation in available soil moisture is one of the main causes of variation in crop yields (Rodriguez-Iturbe *et al*., 2001; Shepherd *et al.*, 2002; Anwar *et al.*, 2003; Patil and Sheelavantar, 2004), an understanding of the water movement with respect to its soil properties in the unsaturated zone is of great importance because of its growing effects in the subsurface environment of plant, which generally reduces the yield of farm produce; causes stress in plant; affect plant growth response and soil conditions which invariably affect tillage and cost of tillage and soil properties depletion from

each zone (Anwar *et al*., 2003 ; Rodriguez-Iturbe *et al*., 2001). Soil properties affect greatly the wetting pattern determination in the unsaturated zone (Clothier and Scotter (2002)).

Knowledge of soil-water behaviour alongside with the infiltration rate in its unsaturated porous media is important to forecast moisture distribution in an irrigated field. Irrigation agriculture is crucial to world food production because of its artificial application of water to the plant which supplements for the highly variable and seasonal rainfall distribution. Drip irrigation technology offers the ability to supply water to crops with increased efficiency, reducing water use as well as nutrient leaching compared to seepage irrigated systems more than other methods of irrigation (Dukes *et al*., 2010; Sato *et al*., 2010). During the dry season irrigation manage water for crop production. The downward entry of water from the surface into the soil profile is referred to infiltration (Lal, 1990). The relationship between the rate of water supply to the soil and the rate of infiltration through it determine the distribution of such water between runoff and storage in the root zone (Pla, 2007). Soil infiltration could be determined by field measurement of point-to-point using a ring infiltrometer. Infiltration is a complex physical process in time and space (Rodríguez-Vásquez *et al*., 2008), which is difficult to characterize with precision under the intrinsic heterogeneous and dynamic soil conditions, which affect the texture, compaction, humidity regime, slope, thickness of the horizons, root development and soil aggregation. The point-to-point field measurement is laborious, tiresome, time consuming and could be a very serious problem and expensive where water is limited (Wuddivira and Abdulkadir, 2000). Soil sorptivity was defined as the gravity-free, capillary-induced absorption (Clothier and Scotter, 2002). It is a measure of the ability of the soil to absorb water without reference to gravitational effects. Sorptivity depends on initial water content (Chong and Green, 1979). Bonsu (1993) reported that sorptivity is important in infiltration studies, since it governs the early stages of infiltration. Sorptivity can also be used to predict time-to-incipient ponding for constant and variable rainfall by using the equations of Mein and Larson (1971) and Parlange and Smith (1976), respectively as reported by Assouline *et al*., (2006). Many methods are available for determining sorptivity with disc infiltration data (Cook and Broeren, 1994; Vandervaere *et al*., 2000a, b and Asiedu *et al*., 2000).

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers (Hossain, *et al.,* 2017). Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish (Hossain, *et al.,* 2017). With drip irrigation, only the part of the soil in which the roots grow is wetted. The objective of this study therefore was to evaluate the effects of drip irrigation regimes on some selected soil properties of an Alfisol grown to tomato (*Lycopersicon esculentum* M.) in south-western Nigeria.

## Materials and Methods

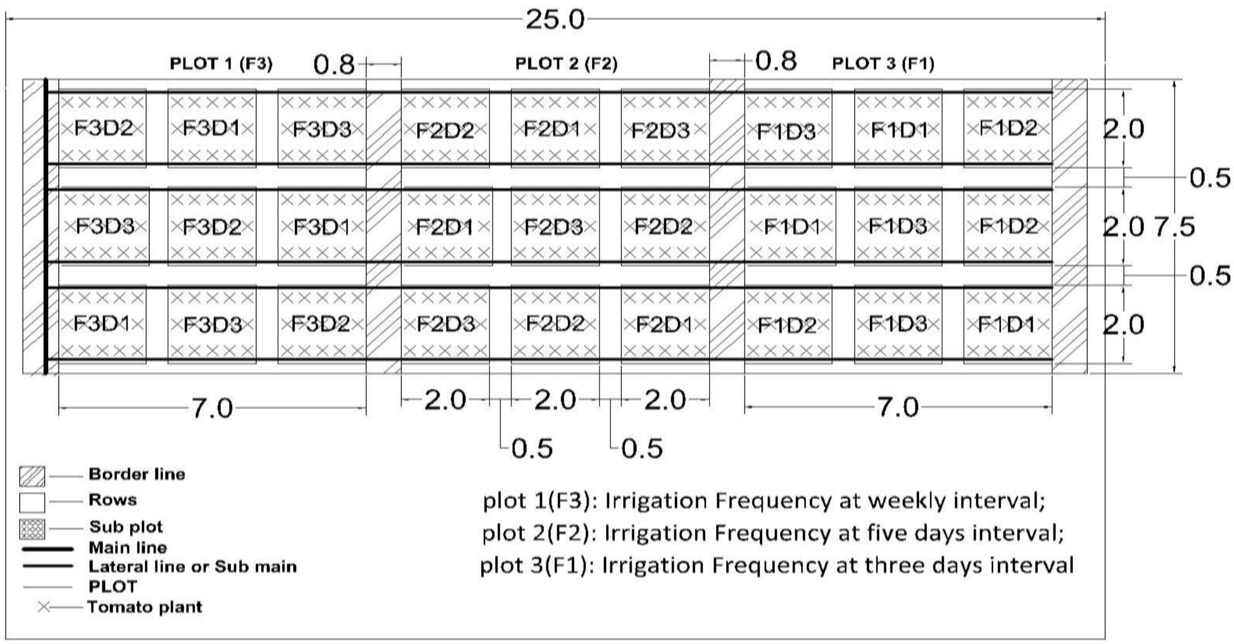
### Description of study site

The tomato drip irrigated field was located at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, ($8^o$ $10^'$N and $4^o$ $10^'$E) in Southwest Nigeria. The experiment was conducted between February and June 2014 early cropping season. Ogbomoso is characterized by bimodal rainfall pattern, peaking in July and September with annual rainfall depth of about 1200 mm (Abegunrin *et al*., 2013) while the mean annual maximum and minimum temperature are 33 and 28 $^oC$ respectively. The climate of the area is cold and dry from November to March and then warm and moist from April to October, it could also be described as a hot humid tropical which falls in southern Guinea Savannah of Nigeria with mean relative humidity of about 74% all year round except in the month of December to February when it is low as a result of dry wind (harmattan) that blows from the north (Olaniyi *et al.*, 2009).

## Experimental design, field and management procedure

The experiment was laid out in a 3x3 randomized complete block design (RCBD) with a split plot arrangement of treatments. Irrigation frequency constituted the main plot while application depth was the subplots in three replications. The irrigation frequency treatments were $F_1$ (weekly), $F_2$(every 5 days)and $F_3$ (every 3 days) while depth of irrigation application are 100, 75 and 50% of tomato evapotranspiration ($ET_C$). Marking out of plot and sub-plots were done according to the experimental design with each plot 7 m × 7 m separated by 1 m pathway and each subplot of 2 m × 2 m and 0.5 m apart. The total area of the experimental field was 7.5 m × 25 m (Fig. 1).

The field was ploughed twice and harrowed once. The position of the tomato seedlings in the sub-plots were marked with pegs according to the recommended spacing of 0.5 x 1 m, to allow easy transplanting of seedlings (Charlo *et al*., 2006). Apart from irrigation treatments, all other agronomic and management practices, such as weeding, fertilizer application, mulching, spraying of insecticides, remained the same in all the plots and sub-plots throughout the growing season.




***All dimensions in m***

F1, F2 and F3 are Frequencies of irrigation at weekly, 5 days and 3 days interval, $D_1$, $D_2$, and $D_3$ are depth of irrigation application at 100, 75 and 50% evapotranspiration ($ET_C$).

**Figure 1.** Field layout of the experiment

*Drip Irrigation System setup:*

The drip irrigation system consists of two 6500 liters capacity tanks mounted at the upper end of the field. Six laterals (made of garden hose), each 25 m long and diameter 15 mm, were laid at each side of the plot with 54 medi-emitters on each laterals. Twelve (12) medi-emitters were laid on each sub-plot (6 to each side of the laterals) with spacing of 0.33 m. The drippers were calibrated on the field to have a discharge of 4L/h using a stop watch and a measuring cylinder of 1 liter capacity. The drippers were fitted to the garden hose (laterals) and the control knob of the dripper was gradually adjusted so that water is allowed to flow at the desired rate.

*Soil sampling and analysis:*

Prior to imposing the irrigation treatments, undisturbed soil samples were collected in the middle of soil layers 0-5, 5-10, 10-20 and 20-30 cm from two representatives points of the field using core samplers of about 58 mm diameter and 40 mm high for the determination of physical properties. Disturbed samples were collected at the same layer for determination of granulometric composition. Before collecting the soil sample, plant litters on soil surface was carefully removed. Samples were kept in sealed plastic cans and transported to the laboratory for analysis.

*Determination of soil texture:*
The granulometric composition was determined using hydrometer method (Gee and Or, 2002) by air-drying the disturbed samples and passing it through a 2 mm sieve according to ASTM 152H standard. The soil textural class was obtained using the textural triangle of the USDA (SSS, 2006 and Nyambane, 2013).

*Determination of bulk density:*
The collected soil cores were oven dried at 105°C for 48 hours to determine the Bulk Density (BD) according to Blake and Hartge (1986).

$$\mathrm{BD} = \frac{\mathrm{M_{ds}}}{\mathrm{V_{sc}}} \quad (1)$$

Where: BD is the bulk density ( $\mathrm{g/cm^3}$); $\mathrm{M_{ds}}$ is the oven dry mass of soil (g); $\mathrm{V_{sc}}$ is the volume of soil in the core ($\mathrm{cm^3}$).

*Determination of soil organic matter:*
The determination of Soil Organic Matter (SOM) content was done according to ASTM D 2974 by placing small amount of already air-dried soil into a furnace, and increase the temperature of the furnace to 440 $^{o}$C then left overnight. The samples were then carefully removed and allowed to cool at room temperature. Then the weight of the container containing ash was determined. The SOM content was calculated using the equation (Kishna, 2002)

$$O_{mc} = \frac{M_o}{M_d} \times 100 \quad (2)$$

where $O_{mc}$ is the organic matter content; $M_o$ is the mass of organic matter; $M_d$ is the mass of dried soil. But;

$$M_o = M_d - M_a \quad (3)$$

where $M_a$ is the mass of the ash (burned) soil.

*Determination of saturated hydraulic conductivity:*
The saturated hydraulic conductivity (*Ks*) was determined using the constant head permeameter method (Klute and Dirksen, 1986). *Ks* is calculated by rearranging the Darcy equation (Oshunsanya, 2011 and Reynolds *et al*., 2000) and computed as

$$Ks = \frac{QL}{H.A.t} \quad (4)$$

Where $\mathrm{K_S}$ is the saturated hydraulic conductivity;Q is the quantity of water ( $\mathrm{cm^3}$);
L is the difference between point A and B (cm);H is the change in the hydraulic head;
A is the cross sectional area ($\mathrm{cm^2}$); t is the time (sec, minutes or hours).

*Soil moisture content monitoring:*
Soil mositure monitoring during the growth cycle was done using gravimetric technique (Krishna, 2002). Soil sample was collected at the middle of soil layers of 0-5, 5-10, 10-20 and 20-30 cm using soil auger. The samples were kept in sealed cans and transported to the laboratory to determine the weight. Thereafter the samples were oven dried at 105$^{o}$C for 48 hours to determine the soil gravimetric moisture content. The soil volumetric water content was determined using the values of bulk density already obtained proir to the conmmencement of the irrigation treatments. Soil moisture monitoring was carried out at 2 days interval throughout the growing season.

$$MC_g = \frac{M_w}{M_{ds}} \times 100 \quad (5)$$

$$M_w = M_{ws} - M_{ds} \quad (6)$$

Where $MC_g$is the gravimetric moisture content ( $cm^3/cm^3$); $M_w$is the mass of water( $g$); $M_{ws}$is the mass of wet soil ( $g$); $M_{ds}$is the mass of dry soil( $g$)
The volumetric soil moisture was obtained according to USDA (2001) using the equation.

$$WC_v = WC_g \times B_d \tag{7}$$

Where $WC_v$ is the volumetric water content (g/cm$^3$); $WC_g$ is the gravimetric soil water content (g/g); $B_d$ is the bulk density( $g/cm^3$).

The sorptivity were analyzed from infiltration data using Kostiakov (1932) and Philip (1957) equations.

$$I = ct^{\propto} \tag{8}$$

$$i = s.t^{0.5} \tag{9}$$

Where I is Cumulative infiltration (cm), C is Initial infiltration (cm min$^{-1}$ or cm h$^{-1}$), $t$ is Elapsed time (sec), α is Index of sorptivity of the soil reflecting the decline of the infiltration rate, S is Sorptivity and embodies the influence of the soil water relation (matric suction and conductivity) in the wetting process.

*Statistical analysis:*
Generally, the data were analyzed using analysis of variance (ANOVA) in Microsoft Excel and SPSS software, the t-test was used to determine whether the bulk density parameters differed from the control and also volumetric moisture content were tested to determine whether difference occurred between soil depths.

## Results and Discussion

The results of the selected soil physical properties of the 0-5, 5-10, 10-20 and 20-30 cm soil depths of the field before the commencement of the experiment are presented in Table 1, while Table 2 showed the soil bulk density of all irrigation treatments of the site after the experiment. From Table 1, the texture for all the four soil depths evaluated were sandy loam, with no appreciable trend in clay content. The pH decreased with soil depth, with the average values ranging between 6.2 and 7.2. The average value of Soil Organic Matter (SOM) was highest (1.8%) in the 0-5 cm surface layer and the SOM decreased with soil depth. The decreasing SOM with increasing depth was due to the humus content which normally reduce with increasing depth. The soil Bulk Density (BD) was lowest in the 0-5 cm superficial layer while the 10-20 and 20-30 cm layers had high BD. Similar trend was observed for the saturated hydraulic conductivity, Ksat, although the 20-30 cm layer had the lowest value of 50.84 mm/h. From Table 2, the BD value obtained for all treatments after completion of irrigation experiment was lowest in the 0-5 cm superficial with minimum and maximum values varied between 1.5 and 1.64 g/cm$^2$ obtained at F2D1 and F3D1, respectively, while 20-30 cm layers had highest BD with minimum and maximum values varied between 1.57 and 1.76 g/cm$^3$ obtained at F1D3 and F1D2, respectively. The BD values obtained after completion of experiment increased with soil depth for treatments F1D1, F2D1, F2D2. F1, F2 and F3 are Frequencies of irrigation at weekly, 5 days and 3 days interval; $D_{1,}$ $D_{2,}$ and $D_3$ are depth of irrigation application at 100, 75 and 50% evapotranspiration respectively.
But there was a slight decrease in BD value for all other treatments F1D2, FID3, F3D2 and F3D3 at 5-10 cm depth with values varying between 1.61 and 1.76, 1.52 and 1.64, 1.54 and 1.70, 1.59 and 1.64 g/cm$^3$ respectively; also F2D3 and F3D1 at 10-20 cm depth with values varies between 1.57 and 1.63, 1.63 and 1.70 g/cm$^3$ respectively. The mean value for each soil depths 0-5, 5-10, 10-20 and 20-30 cm are 1.57, 1.58, 1.64 and 1.67 g/cm$^3$ respectively. The mean value for all soil depths in all treatments ranged from 1.58 and 1.69.

**Table 1.** Selected soil physical properties of the site before the experiment.

| Soil depth, cm | SOM % | BD g/cm$^3$ | Ksat mm/hr | Sand | Silt | Clay | Texture |
|---|---|---|---|---|---|---|---|
| | | | | ---------- | % | ---------- | |
| 0-5 | 1.8 | 1.48 | 52.07 | 80.5 | 8.1 | 11.4 | SL |
| 5-10 | 1.2 | 1.62 | 51.09 | 77.6 | 12.0 | 10.4 | SL |
| 10-20 | 1.2 | 1.70 | 54.10 | 79.7 | 10.1 | 10.2 | SL |
| 20-30 | 1.0 | 1.73 | 50.84 | 76.3 | 13.2 | 11.5 | SL |

pH: level of alkalinity or acidity, K: potassium, Ca: calcium, Mg: magnesium, SOM: soil organic matter, BD: bulk density, Ksat: saturated hydraulic conductivity, SL: sandy loam.

**Table 2.** Soil bulk density of all irrigation treatment in the site after the experiment

| Soil depth, cm | F1D1 ......... | F1D2 ............... | F1D3 ............. | F2D1 .......... | F2D2 g/cm$^3$ | F2D3 ............ | F3D1 ............. | F3D2 ........... | F3D3 ........... | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-5 | 1.55 | 1.63 | 1.61 | 1.5 | 1.52 | 1.57 | 1.64 | 1.55 | 1.6 | 1.57 |
| 5-10 | 1.58 | 1.61 | 1.52 | 1.51 | 1.6 | 1.61 | 1.66 | 1.54 | 1.59 | 1.58 |
| 10-20 | 1.63 | 1.75 | 1.64 | 1.66 | 1.6 | 1.6 | 1.63 | 1.59 | 1.62 | 1.64 |
| 20-30 | 1.74 | 1.76 | 1.57 | 1.69 | 1.61 | 1.63 | 1.7 | 1.7 | 1.64 | 1.67 |
| Mean | 1.62 | 1.69 | 1.585 | 1.59 | 1.58 | 1.60 | 1.66 | 1.60 | 1.61 | |

F1, F2 and F3 are Frequencies of irrigation at weekly, 5 days and 3 days interval;$D_1$, $D_2$, and $D_3$ are depth of irrigation application at 100, 75 and 50% evapotranspiration ($ET_C$), respectively.

Generally, there is an increase in bulk density value obtained after completion of the experiment at 0-5 cm depth when compared with value obtained before the experiment. This may be due to gradual soil compactions that occur after primary and secondary tillage operation which affects the variability of volumetric water content for both the surface and subsurface layer of the soil. However, the subsurface layers shows an increase in bulk density value obtained after completion of the experiment for only F3D1 at 5-10 cm and F1D2 at 10-20 and 20-30 cm depth when compared with value obtained before the experiment. The increase in BD indicates a reduction in the size, number of macro-pores (Bottinelli *et al.*, 2016).
Table 3 showed the t-test summary of analyzed BD results for all treatments, there was no significant difference ($p < 0.05$) between the control and all the treatments for 0-5 cm depth. At 5-10 cm depths all F1 treatments showed no significant difference with the control while F2 and F3 treatments showed significant differences. At depths 10-20 cm and 20-30 cm all treatments varied significantly ($p < 0.05$) with the control except for F2D1 treatment at 10-20 cm depth. It was also observed that the variation among the treatments increased with soil depth.

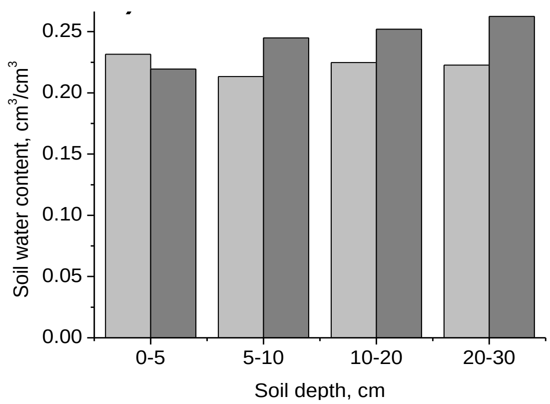
**Table 3.** The summary of analyzed Bulk density results showing all treatments

| | 0-5 cm | 5-10 cm | 10-20 cm | 20-30 cm |
|---|---|---|---|---|
| Control | $1.48_a$ | $1.62_b$ | $1.67_b$ | $1.73_c$ |
| F1D1 | $1.55_a$ | $1.58_b$ | $1.63_c$ | $1.74_d$ |
| F1D2 | $1.63_a$ | $1.61_b$ | $1.75_c$ | $1.76_c$ |
| F1D3 | $1.61_a$ | $1.52_b$ | $1.64_c$ | $1.57_d$ |
| F2D1 | $1.47_a$ | $1.51_a$ | $1.66_b$ | $1.69_b$ |
| F2D2 | $1.52_a$ | $1.57_{a,b}$ | $1.57_{a,b}$ | $1.61_b$ |
| F2D3 | $1.57_a$ | $1.61_{a,b}$ | $1.57_a$ | $1.63_b$ |
| F3D1 | $1.64_a$ | $1.66_a$ | $1.63_a$ | $1.67_a$ |
| F3D2 | $1.55_a$ | $1.54_a$ | $1.59_a$ | $1.67_b$ |
| F3D3 | $1.57_a$ | $1.59_{a,b}$ | $1.62_{a,b}$ | $1.64_b$ |

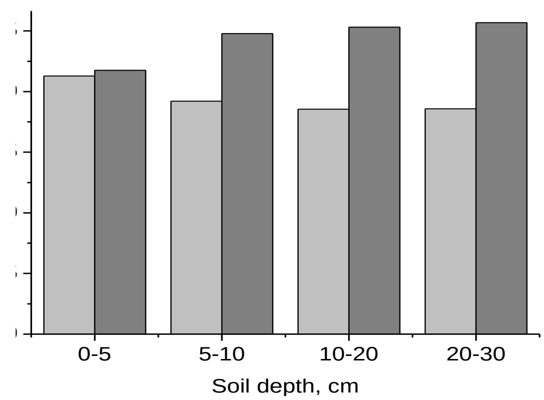
Note: Values in the same row not sharing the same subscript are significantly different at p< .05 in the two-sided test of equality for column means.

Figure 2 (*a, b and c)* of F1 treatments shows that surface soil volumetric water content (0-5 cm layer) between the start and end of irrigation followed no obvious trends for all treatments. This is because the effects of evaporation, seepage and drainage are the same at the surface of the soil. However, for all subsurface layers the soil volumetric water content after irrigation increased when compared with before irrigation experiment. A similar trend was obtained for all soil depths in F2 and F3 treatments (Figures 3 and 4). This is similar to the result of Bianne *et al* (2003).

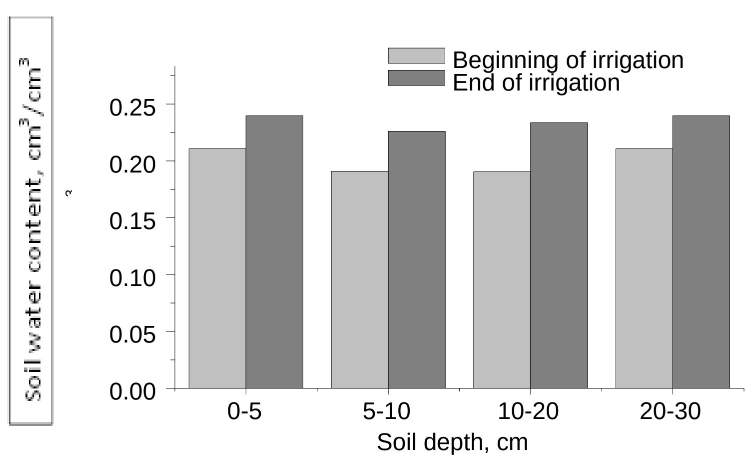
Most of these alterations in the soil physical environment caused by soil mobilization are mediated through its effect on BD. The low BD of the surface layer is attributed to top soil mobilization by tillage operation which was carried out on the field before the experiment, while increase BD observed in all the sub surface layer after the experiment (Table 2) is attributed to soil compaction among other factors.




**(a)**

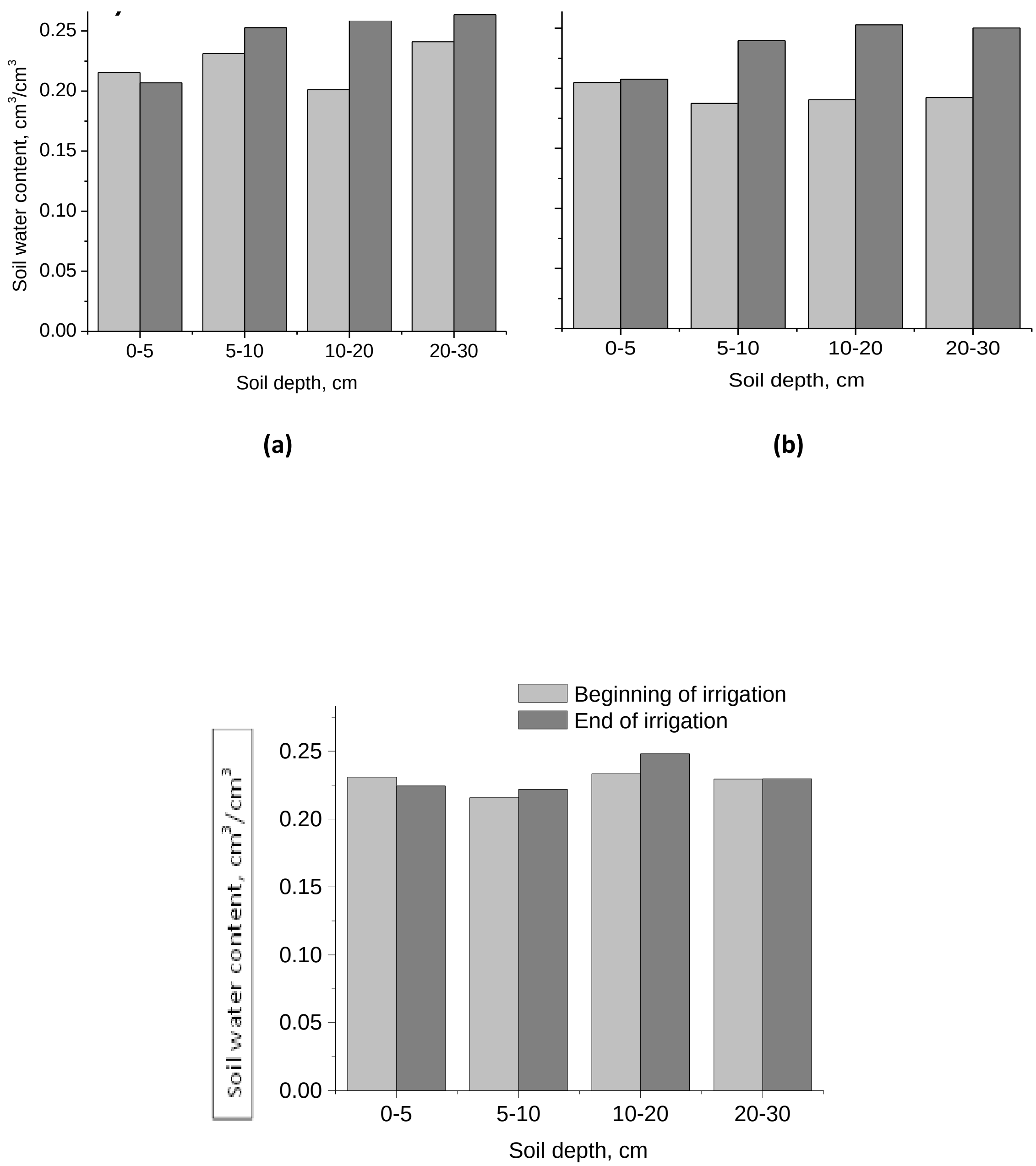



**(b)**




**(c)**

**Figure 2.** Soil volumetric water content for the various depths at the beginning and end of the experiment irrigated weekly (F1) and different irrigated depths (a) 100% ETc (D1), (b) 75% ETc (D2), and (c) 50% ETc (D3).




(a) (b)

(c)

**Figure 3.** Soil volumetric water content for the various depths at the beginning and end of the experiment irrigated weekly (F2) and different irrigated depths (a) 100% ETc (D1), (b) 75% ETc (D2), and (c) 50% ETc (D3).

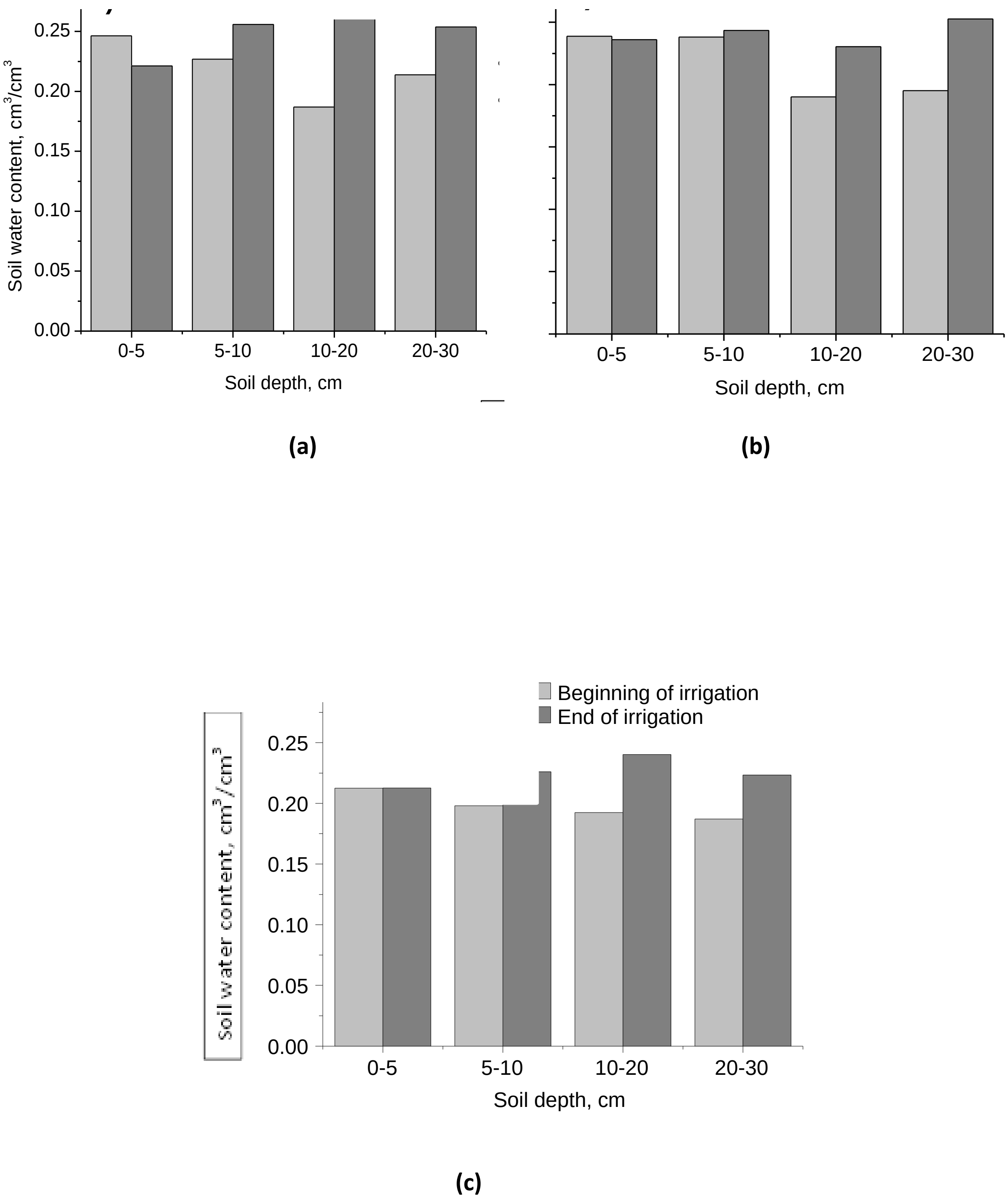



**Figure 4**. Soil volumetric water content for the various depths at the beginning and end of the experiment irrigated weekly (F3) and different irrigated depths (a) 100% ETc (D1), (b) 75% ETc (D2), and (c) 50% ETc (D3).

Soil dry BD can decrease because of primary and secondary tillage (Fraser *et al*., 2010). On the other hand, the increased BD in the subsurface layers may be due to several factors including alternate wetting and drying cycle due to irrigation. BD increases as soil settles because of, irrigation (Meek *et al*., 1992; Fraser *et al*., 2010).

However, from Table 1, a comparison of the BD values of sandy loam soil in the subsurface layers with recommended values showed that they were less than the threshold BD value of 1.75 $g/cm^3$ (Reinert *et al*., 2008), indicating that the soil has not reached the condition considered restrictive to root growth, water dynamics and gaseous exchange. But after the irrigation experiment from Table 2 a comparison of the BD values of all subsurface layers with recommended values showed that they were higher, which is still good because at this period the root growth has reached it maximum.

Clay content plays a significant role in soil water retention because of higher micropore volume and surface area, however, the clay content of the four layers was similar, indicating that no layer retain more water than the other (Nazile Ural, 2018).

The behavior saturated hydraulic conductivity (Ks) which is a dynamic property of the soil is determined by the degree of soil compaction (Reichert *et al*., 2007) also, it is highly dependent on the shape, arrangement, quantity and continuity of pores in the soil (Mesquita and Moraes, 2004). The lowest Ks obtained in the 20-30 cm layer was as a result of high BD, meaning this layer composed of fewer macropores that are responsible for water transmission. The reduction in soil hydraulic conductivity could affect infiltration water through the soil profile and also affects water movement across the landscape (Coppola *et al*., 2004). Also, the indiscernible trend in the Ks in three superficial layers may be due to complex interaction between the soil BD, porosity and structure (Reichert *et al*., 2007).

The high organic matter in the surface soil is due to the decomposition of plant residue under fallow condition which is an indication of better aggregation and improved pore space with reduced bulk density. Decomposition of crop residue leads to increase in soil organic matter and the high organic matter improve soil water holding capacity, especially in sandy and clay soils Rawls *et al*. (2003). The lower SOM content in the subsurface layers is attributed to low biological activity resulting in no plant residue.

The results of infiltration rate for all treatments are presented in Figure 5. At the initial infiltration, the highest value (about 21.58 l/day) of infiltration was obtained from the F2 treatment while the lowest value was obtained from the F3 treatment about 2.56 during the growing period. At the beginning of the experiment the minimum and maximum values are 7.02 and 11.54 l/day obtained at F1 and F2 treatments while at the end of the experiment minimum and maximum value are 2.56 and 4.04 l/day obtained at F3 and F1 respectively. Also for the final infiltration rate, the highest and the lowest value were obtained at F3 and F1 treatment 6.73 and 1.57 l/day, but at the beginning of the experiment, the minimum and maximum value are 3.78 and 6.29 l/day obtained at F1 and F2 treatment and at the end of experiment the minimum and maximum value are 1.76 and 2.57 l/day obtained at F3 and F1 treatment. From the graph, the initial infiltration rate is faster than the final infiltration rate. Generally, the lower the initial soil moisture content is, the higher the initial soil infiltration rate will be (Lili *et al*. 2008). The beginning of experiment was around the dry season when the initial soil moisture was low due to dry soils, at these period, the high infiltration rate may be due to low water content in the soil pore space, while at end, of experiment, low infiltration rate may be due to soil pore space been filled with water. During the growing season, infiltration rate is determined by alternate wetting and drying (Lili *et al*. 2008).

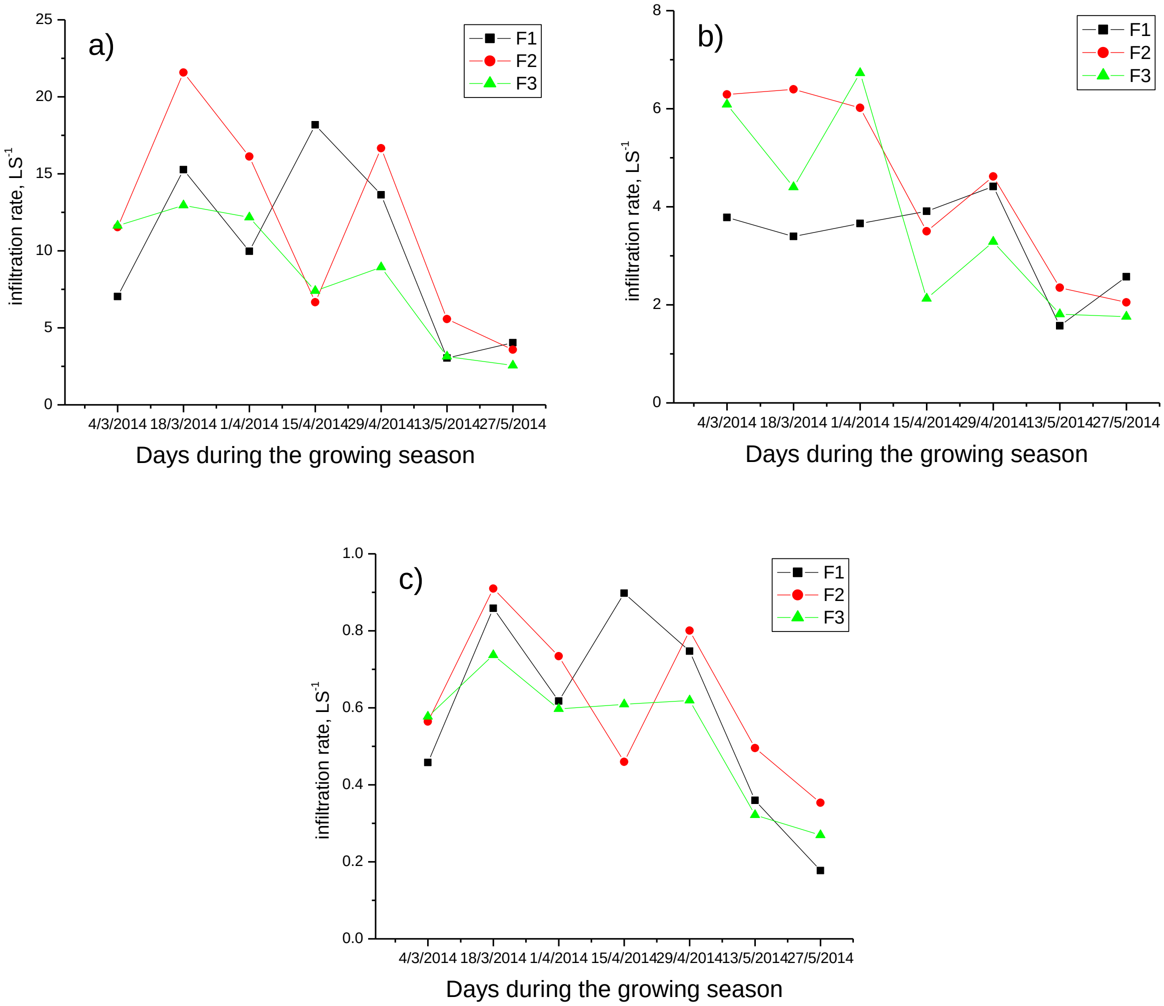



**Figure 5**. The infiltration results showing irrigation frequency treatments $F_1$ (weekly), $F_2$ (every 5 days) and $F_3$ (every 3 days) for the (a) initial infiltration rate, (b) final infiltration rate, (c) initial sorptivity.

Sorptivity (S) measures soil's ability to absorb water without gravitational effect. For the initial S-rate the highest value (about 0.90 cm $s^{0.5}$) was obtained at the F2 treatment while the lowest value was obtained at F1 treatment about 0.18 cm $s^{0.5}$, but at the beginning of the experiment the minimum and maximum value are 0.46 and 0.58 cm $s^{0.5}$ obtained at F1 and F3 treatments and at the end of experiment the minimum and maximum values are 0.18 and 0.35 cm $s^{0.5}$ obtained at F1 and F2 treatments. Generally for the initial infiltration rate, final infiltration rate and S there was a rapid reduction in the infiltration rate between the start and end of the experiment. This may be due to increasing water content present in soil macro and micro pores. F2 was the highest S at the beginning and at the end of the experiment indicating the best drained soil water which may have more macro-pores than the others. These showed that F2 treatment had the greatest ability to absorb and conduct initial water during infiltration. The reverse was true for F3 treatment which almost recorded the lowest infiltration rate during the growing period. Low S may cause high runoff whenever rainfall intensity exceeds the infiltration rate and also ponding problem on land surface (Asiedu *et al*., 2000).

The summary of analyzed soil volumetric water content for all treatments across each soil depths is shown in Table 4, comparing the frequencies with depths D1, D2 and D3 it was observed that there was no significance difference for all the soil depths at ($p < 0.05$). Also, the summary of analyzed soil volumetric water content for all treatments across each soil depths Table 5, comparing down depth of soil profile there was significant difference ($p < 0.05$) for treatments F2D1, F2D3, F3D1 and F3D3.

**Table 4.** The summary of analyzed soil volumetric water content for all treatments across each soil depths [0-100cm]

| Depth | F1 | | | F2 | | | F3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | D1 | D2 | D3 | D1 | D2 | D3 | D1 | D2 | D3 |
| 0-5 cm | $0.11^{a}$ | $0.11^{a}$ | $0.10^{a}$ | $0.10^{a}$ | $0.10^{a}$ | $0.10^{a}$ | $0.10^{a}$ | $0.09^{a}$ | $0.10^{a}$ |
| 5-10 cm | $0.12^{a}$ | $0.14^{a}$ | $0.12^{a}$ | $0.14^{a}$ | $0.12^{a}$ | $0.12^{a}$ | $0.13^{a}$ | $0.12^{a}$ | $0.11^{a}$ |
| 10-20 cm | $0.11^{a}$ | $0.12^{a}$ | $0.11^{a}$ | $0.12^{a}$ | $0.13^{a}$ | $0.12^{a}$ | $0.11^{a}$ | $0.12^{a}$ | $0.14^{a}$ |
| 20-30 cm | $0.12^{a}$ | $0.12^{a}$ | $0.12^{a}$ | $0.13^{a}$ | $0.11^{a}$ | $0.11^{a}$ | $0.11^{a}$ | $0.12^{a}$ | $0.12^{a}$ |

Note: Values in the same row not sharing the same subscript are significantly different at $p< 0.05$.

**Table 5.** The summary of analyzed soil volumetric water content for all treatments across each soil depths

| Depth | Frequency | 0-5 cm | 5-10 cm | 10-20 cm | 20-30 cm |
|---|---|---|---|---|---|
| D1 | F1 | $0.11^{a}$ | $0.12^{a}$ | $0.11^{a}$ | $0.12^{a}$ |
| | F2 | $0.10^{a}$ | $0.14^{b}$ | $0.12^{a,b}$ | $0.13^{b}$ |
| | F3 | $0.10^{a}$ | $0.13^{b}$ | $0.11^{a,b}$ | $0.11^{a}$ |
| D2 | F1 | $0.11^{a}$ | $0.14^{a}$ | $0.12^{a}$ | $0.12^{a}$ |
| | F2 | $0.10^{a}$ | $0.12^{a}$ | $0.13^{a}$ | $0.11^{a}$ |
| | F3 | $0.09^{a}$ | $0.12^{a}$ | $0.12^{a}$ | $0.12^{a}$ |
| D3 | F1 | $0.10^{a}$ | $0.12^{a}$ | $0.11^{a}$ | $0.12^{a}$ |
| | F2 | $0.10^{a}$ | $0.12^{a,b}$ | $0.12^{b}$ | $0.11^{a,b}$ |
| | F3 | $0.10^{a}$ | $0.11^{a,b}$ | $0.14^{b}$ | $0.12^{a,b}$ |

Note: Values in the same row not sharing the same subscript are significantly different at $p< 0.05$.

**Conclusion**

The study showed that the soil bulk density value before and after irrigation experiment ranged from 1.48 and 1.73 $g/cm^3$ and 1.5 and 1.76 $g/cm^3$, respectively. Also, sorptivity ranged from 0.18 and 0.90 cm $s^{0.5}$. It was observed that there was no significance difference in the analyzed soil volumetric water content for all the soil depths at ($p < 0.05$). while there was significant difference ($p < 0.05$) across each soil depths It was established that the soil properties especially bulk density and organic matter content affects the behavior of soil volumetric water content before and after completion of irrigation experiment and soil infiltration rate is affected by initial moisture content. Hence, soil properties especially bulk density and organic matter content affect irrigation water movement at different depth. Irrigation frequemcy at five days interval had the greatest ability to absorb and conduct initial water during infiltration. It is recommended that other soil properties of drip irrigated vegetables under more irrigation frequencies should be investigated.

## References

Abegunrin, T.P., Awe, G.O., Idowu, D.O., Onigbogi, O.O. and Onofua, O. E., (2013). Effect of kitchen wastewater irrigation on soil properties and growth of cucumber (*Cucumis sativus*). *Journal of Soil Science and Environmental Management.* 4(7): 139-145.

Adekiya, A.O., Ojeniyi, S.O., (2002). Evaluation of tomato growth and soil properties under methods of seedling bed preparation in an Alfisol in the rainforest zone of southwest Nigeria. *Bioresource Technol.* 96: 509-516.

Anwar, M. R., McKenzie, B. A., Hill, G. D., (2003). Water-use efficiency and the effect of water deficits on crop growth and yield of kabuli chickpea (Cicer arietinum L.) in a cool-temperate sub-humid climate, *J. Agric. Sci.*, 141: 285–301.

Asiedu, E. K., Ahenkorah, Y., Bonsu, M., Oteng, J. W., (2000). Infiltration and sorptivity studies on some landform technologies for managing Vertisols.Ghana. *Jni Agric. Sci* 33,147-152.

Assouline, S., Selker, J.S. and J.Y. Parlange. (2007). A simple accurate method to predict time of ponding under variable intensity rainfall. *Water Resources Research,* Vol. 43, W03426, doi:10.1029/2006WR005138.

Bianne, R.H., Donald, W.M. and Larry, J.S. (2003) Effect of Irrigation Frequency on Subsurface Drip Irrigated Vegetables. *HortTechnology.* 13(1) : 115-120

Blake, G.R., Hartge, K.H., (1986). Bulk density. In: Klute A (Ed.). Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods, 2nd edn. AS. SSSA, Madison. USA. pp. 363.

Bonsu, M., (1993). Field determination of sorptivity as a function of water content, using tension infiltrometer. *1. Soil Sci*. 44,411-415.

Bottinelli, N., Zhou, H., Boivin, P., Zhang, Z. B., Jouquet, P. , Hartmann, C.and Peng, X. (2016). Macropores generated during shrinkage in two paddy soils using X-ray micro-computed tomography. *Geoderma*. 265: 78 - 86

Charlo, H.C.O., Castoldi, R., Ito, L.A., Fernandes, C., Braz, L.T., (2006). Productivity of cherry tomatoes under protected cultivation carried out with different types of pruning and spacing.

Chong, S. K., Green, R. E., (1979). Application of field measured sorptivity for simplified infiltration prediction. In Proceedings of the Hydrologic Transport M.odelling Symposium Publication 4-80, 88-96. New Orleans, 'LA, American Society of Agricultural Engineers.

Clothier, B., Scotter, D., (2002). Unsaturated water transmission parameters obtained from infiltration. Methods of soil analysis. Madison, *Soil Science Society of America.* 879-898.

Coppola, A., Santini, A., Botti, P., Vacca,S., Comegna, V., Severino, G., (2004). Methodological approach for evaluating the response of soil hydrological behaviour to irrigation with treated municipal waste water. *Journal of Hydrology*, 292: 114-134.

Dukes, M.D., Zotarelli, L., Morgan, K.T., (2010). Use of irrigation technologies for vegetable crops in Florida. *Hort Technology* **20**: 133-142.

Ewulo, B. S. Ojeniyi, S. O., Akanni, D. A., (2008). Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. African Journal of Agricultural Research. 3(9):612-616. http://www.academicjournals.org/AJAR (accessed 2009 November 10).

Fraser, P. M., Curtin, D., Beare, M. H., Meenken, E. D., Gillspie, R. N., (2010). Temporal changes in soil surface elevation under different tillage systems. Soil Sci. Soc. Am. J. 74:1743Y1749.

Gee, G.W., Or, D., (2002). Particle-size analysis, In Methods of Soil Analysis, Part 4, SSSA Book Series, edited by: Dane, J. and Topp, C. American society of Agronomy, Madison, Wisconsin. **5**: 255-294.

Hossain S.A., Lixue W., M.E. Uddin, Dan L., Haisheng L. and Siping L. (2017). Contemporary Perspective of Drip Irrigation: A Review of Water Savimg Crop Production. Asian Research Journal of Agriculture. 3(4); 1-22.

Ikpe, F.N., Powell, J.M., (2002). Nutrient cycling practices and changes in soil properties in the croplivestock farming systems of western Niger Republic of West Africa. *Nutrient Cycling Agroecosystems*. 62: 37-45.

Klute, A., Dirksen, C., (1986). Hydraulic conductivity and diffusivity: laboratory methods. In: Methods of soil analysis, Part 1, physical and mineralogical methods, Klute A. (Ed.). ASA and SSSA, Madison, Wisconsin, USA. Pp .668-734.

Krishna, R.R., (2002). Engineering properties of soils based on laboratory testing. Department of Civil and Materials Engineering University of Illinois, Chicago.

Lal, R., (1990). Tropical Soils: Distribution properties and management. Resource Management and Optimization 7: 39–52.

Lili, M., Bralts, V. F., Yinghua, P., Han L., Tingwu, L. (2008). Methods for measuring soil infiltration," State of the art, *Int J Agric & Biol Eng.* 1(1): 22-30.

Meek, B. D., Rechel, E. R., Carter, L. M., DeTar, W. R., (1992). Bulk density of a sandy loam: Traffic, tillage, and irrigation-method effects. *Soil Sci. Soc. Am. J*. 56:562Y565

Mein, R. C., Larson, C. L., (1971). Modeling infiltration component of the rainfall-runoff process. Water Resources Research Centre, University of Minnesota Bulletin No. 43. Minneapolis, USA.

Mesquita, M. G. B. F., Moraes, S. O., (2004). A dependência entre a condutividade hidráulica saturada e atributos físicos do solo. Ciência Rural, Santa Maria, 34(3):963-969.

Nazile Ural (2018). The Importance of Clay in Geotechnical Engineering, Current Topics in the Utilization of Clay in Industrial and Medical Applications, Mansoor Zoveidavianpoor, IntechOpen, DOI: 10.5772/intechopen.75817.

Nnabude, P.C., Mbagwu, J.S.C., (2001). Physio-chemical properties and productivity of a Nigerian Typic-Hapluustult amended with fresh and burnt rice-mill wastes. *Bioresource. Tech*.,76: 265 – 272.

Nnabude, P.C., Agunwamba, J.C., Mbagwu, J.S.C., (2000). Modeling Infiltration Rate in Conditioned Soil: Comparisons and Modifications. *Int. Agrophys*. 14: 393 – 400.

Nyambane, O., (2013). Civil engineering construction. Department of Real Estate and Construction Management, University of Nairobi. pp1-49.

Olaniyi, J.O., Akanbi, W.B., Adejumo, T.A., Akande G.O., (2009). Growth, fruit yield and nutritional quality of Tomato varieties. African Journals of food Science. **4(6)**: 398-402.

Obi, M.E., Ebo, P.O., (1995). The effect of organic and inorganic amendments on soil physical properties and maize production in a severely degraded sandy soil in southern Nigeria. *Bio-resource Technology*. 51: 117-123.

Oshunsanya, S.O., (2011). Soil physics textbook. Department of Agronomy, University of Ibadan, Nigeria. pg. 101-109.

Parlange, J. Y., Smith, R. E., (1976). Ponding time for variable rainfall rates. *Can. 1. Soil Sci.* 56, 121-123.

Patil, S. L., Sheelavantar, M. N., (2004). Effect of cultural practices on soil properties, moisture conservation and grain yield of winter sorghum in semi-arid tropics of India. *Hydrol. Process.* 64: 49–67.

Philip, J.R., (1957). The theory of infiltration: 1. The infiltration equation and its solution. *Soil Sci.*, 83:345-357.

Pla, S., (2007). Infiltration. Paper presented at College on Soil Physics. *In* Abdus Salam International Centre for Theoretical Physics. Trieste, Italy.

Rawls, W.J., Pachepsky, Y.A., Ritchie, J.C., Sobecki, T.M., Bloodworth. H., (2003). Effect of Soil Organic Carbon on Soil Water Retention. *Geoderma* 116:61–76.

Reichert, J.M., Suzuki, L.E.A.S., Reinert, D.J., (2007). Compactação do solo em sistemas agropecuários e florestais: identificação, efeitos, limites críticos e mitigação. In: CERETTA, C.A.; SILVA, L.S. da; REICHERT, J.M. (Ed.). *Tópicos em ciência do solo. Viçosa: Sociedade Brasileira de Ciência do Solo.*5:49-134.

Reinert, D.J., Albuquerque, J.A., Reichert, J.M., Aita, C., Andrada, M.M.C., (2008). Limites críticos de densidade do solo para o crescimento de raízes de plantas de cobertura em Argissolo Vermelho. Revista Brasileira de Ciência do Solo. 32:1805-1816.

Reynolds W.D., Bowman B.T., Brunke R.R., Durry C.F., Tan C.S., (2000). Comparison of tension infiltrometer, pressure infiltrometer, and soil core estimates of saturated hydraulic conductivity. *Soil Science Society of America Journal*. 64: 478–484.

Rodriguez-Iturbe, I., Porporato, A., Laio, F., Ridolfi, L., (2001). Plants in water-controlled ecosystems: Active role in hydrologic processes and response to water stress. Adv. Water Resoucr. 24(7): 695–705.

Rodríguez-Vásquez, A.F., Aristizábal-Castillo, A.M., Camacho-Tamayo, J.H., (2008). Variabilidad espacial de los modelos de infiltración de Philip y Kostiakov en un suelo Ándico. Engenharia Agrícola 28:64-75.

Sato, S., Morgan, K.T., Ozores-Hampton, M., Mahmoud, K., Simonne, E.H., (2010). Nutrient balance and use efficiency in sandy soils cropped with tomato under seepage irrigation. *Soil Science Society of America Journal.* **76**: 1867-1876.

Shepherd, A., Mc Ginn, S. M., Wyseure, G. C. L., (2002). Simulation of the effect of water shortage on the yields of winter wheat in north-east England. Ecol. Modell. 147: 41–52.

Soil Survey Staff (SSS)., (2006). Keys to soil taxonomy. 10thed. Washington, USDA-SCS, P. 332.

USDA-NRCS., (2001).Estimating soil moisture by feel and appearance. http://www.mt.nrcs.usda.gov/technical/ecs/agronomy/soilmoisture/ (visited 14 April 2004).

Vandervaere, J.P., Vauclin, M., Elrick, D.E., (2000a). Transient flow from tension infiltrometers:1. The two-parameter equation. *Soil Sci. Soc. Am. J.*, 64: 1263-1272.

Vandervaere, J.P., Vauclin, M., Elrick, D.E., (2000b). Transient flow from tension infiltrometers: 2. four methods to determine sorptivity and conductivity. *Soil Sci. Soc. Am. J.*, 64: 1272-1284.

Wuddivira, H.N., Abdulkadir, A., (2000). Determination of infiltration characteristics of a Typic Haplustalf in Samaru, Northern Guinea Savanna, Nigeria, Babalola, (ed.). Proceedings of the 26th Annual Conference of the Soil Science Society of Nigeria. pp. 99 - 101.