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PERFORMANCE EVALUTION OF A LOCAL DRIP IRRIGATION SYSTEM FOR VEGETABLE PRODUCTION

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ABSTRACT
This study was conducted to evaluate the performance of an air tight local drip irrigation system. It evaluates the water distribution efficiency, considering the water quality and the duration of usage. The water distribution efficiency, water physicochemical analysis, soil analysis were determined for the drip irrigation system. All parameters were found to be below the level of concern. The procedures were based on taking measurement of emitter discharge along selected drip lines on a sub-main. Twenty water discharge were collected using sample containers results recorded. Results indicated that the uniformity of water application was 80% indicating that the emitter is good. The average discharge rates were 0.14 l/h, 0.16 l/h, 0.19 l/h, 0.20 l/h, 0.22 l/h, 0.24 l/h, 0.26l/h and 0.31 l/h respectively. The water distribution efficiencies at different air intakes are: 79.5%, 79.5%, 80%, 80% 79.5%, 79.5%, 79.5% and 79.5% respectively indicating good water application and was quite significant for the evaluation of the uniform distribution of water. The constructed drip irrigation system in this has shown that drip pipe network can be used for different plant with similar water requirement and spacing, this will save the cost of changing pipe network each time there is changes in crop with similar water requirement and spacing. In this research work the rate of discharge depends on the volume of air entering the system water tank. All the materials used in this construction are locally sourced materials.

KEYWORDS: *Irrigation system, Physicochemical Analysis, Drip pipe.*

1. INTRODUCTION

Irrigation is defined as the application of water, supplementary to that supplied directly by precipitation, for the production of crops, (James, 2009). Rain water for agriculture is erratic in which man cannot depend solely on it for farming activities without supplementary application of water hence the need for artificial application of water cannot be underestimated in achieving a sustainable agriculture.

Overtime there is need for a growing economy and need for self-sustainability in food production and this necessitates the introduction of irrigation as a method to boost it. Irrigation is a method that comes into play as one of the means of improving total volume or reliability of agricultural production by managing water for the crop (Essien and Essien, 2014). The world trend in irrigation is such that the total irrigated area was estimated 311 million hectares (Adetiminrin *et al.,* 2008).

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. In other words, it is the artificial application of water directly to the root zone of the plants by means of dripping. The goal is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of pipes, valves, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation. (Wang *et al.,* 2006).

Drip irrigation is becoming popular especially in areas where water supplies are limited or recycled for irrigation. Careful study of all the relevant factors such as land topography, soil water crop and agro-climatic conditions are needed to determine the most suitable irrigation system. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of impact sprinklers in the 1930s, which offered the first practical alternative to surface irrigation. Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters. These are generally used on tree and vine crops with wider root zones. Subsurface drip irrigation (SDI) uses permanently or temporarily buried dripper line or drip tape located at or below the plant roots.

It is obvious that the world population is increasing rapidly, therefore, the challenge for meeting the food need of the growing population must be considered. Based on this fact, irrigation will be of great importance in increasing food production, unfortunately, the needed attention is not given to irrigation practices especially in this part of the northern Nigeria where water is insufficient. Therefore, for sufficient utilization of this rainfall, the drip irrigation system will conserve adequately the limited available water supply (Essien and Essien, 2014).

Two distinct climatic seasons are present in Northern Nigeria, the wet and dry season. Average rainfall begins in the North in the month of May and ends in October while the dry season begins from October and ends in April. It is then obvious to conclude that, the dry and wet seasons in this part of the country is relatively equal in duration and the water available is less when compare to the southern part of the country where rainfall duration is high thus necessitate for more judicious use and application of water for agriculture.

The need for an affordable small scale irrigation system in most farms in Nigeria today is on the increase and as a result, an attempt has been made to design a drip irrigation set for vegetables cultivation. This encompasses taking all human actions/efforts required to optimize the utilization of available water for agricultural purposes. From the available literature review (Wang *et al.,* 2006) drip irrigation system is one of the best methods to preserve water when it comes to irrigated farming, therefore this research is expected to improve the rate at which water is being reserve for agricultural practices, this in turn makes water available to boost agricultural production. The study evaluate the performance of local drip irrigation system for vegetable production.

1.1 Irrigation and Types of Irrigation Scheme

Surface irrigation

Surface irrigation is a technique where water is applied and distributed over the soil surface by gravity. It is by far the most common form of irrigation throughout the world and has been practiced in many areas virtually unchanged for thousands of years. Surface irrigation is often referred to as flood irrigation, implying that the water distribution is uncontrolled and is, inherently inefficient. In reality, some of the irrigation practices grouped under this name involve a significant degree poor water of management. Surface irrigation comes in three major types: level basin, furrow and border strip.

Basin irrigation has historically been used in small areas having level surfaces that are surrounded by earth banks. The water is applied rapidly to the entire basin and is allowed to infiltrate. Basins may be linked sequentially so that drainage from one basin is diverted into the next, once the desired soil water deficit is satisfied. A "closed" type basin is one where no water is drained from the basin. Basin irrigation is favoured in soils with relatively low infiltration rates. (Benami *et al.,* 2002).

Sprinkler irrigation

With sprinkler irrigation, artificial rainfall is created. The water is carried to the field through a pipe system in which the water is under pressure. The spraying is accompanied by using several rotating sprinkler heads or nozzles or a single gun type sprinkler (Benami *et al.,* 2002).

Drip irrigation

Africa's regions with extensive periods of drought and inadequate rainfall contribute to the continent's food shortage problem. While nature cannot be controlled, society does have the ability to develop and practice more efficient water usage techniques in order to improve global fresh water supply. One type of technology that may contribute to the improvement of water supply management and the associated food crisis is drip irrigation. Drip irrigation systems (DIS) have discharge points or sufficiently small holes in sections of hose such that filtration is a primary concern. These systems commonly use low flow rates and low pressures at the emitters and are typically designed to only wet the root zone and maintain this zone at or near an optimum moisture level. Hence, there is a potential to conserve water losses by not irrigating the whole field. (Burt and Styles, 1994).

Obvious advantages of drip irrigation include a smaller wetted surface area, minimal evaporation and weed growth, and potentially improved water application uniformity within the crop root zone by better control over the location and volume of water application (Hoffman and Martin, 1993). Drip systems are also commonly designed to include fertigation and automation capabilities. (Burt and Styles, 1994).

In recent years, low-pressure drip irrigation (LPDI) systems have been developed for smaller farming areas. For many subsistence farmers, a standard pressurized system is too expensive and complicated, as pressurized systems are intended for large areas of land, and therefore do not match the needs of small subsistence farming (Bustan, 2008).

LPDI systems work with gravity-power and are low water pressure; there is no longer a need for operation by an outside power source, thus reducing the initial cost. With the bottom of the water reservoir sitting at 1-2 m above the ground, these systems can generate a flow of about 1 m3/h (Phocaides, 2007). Dov Pasternak, a drip irrigation specialist from Israel, has combined the LPDI system with an appropriate crop mix to create the African Market Garden (AMG), but for this design the bottom was set at a height of 0.80 m above ground. The AMG generates revenue for small farmers and has been implemented in West African countries such as Senegal, Ghana and Niger etc. Drip systems provide not only the potential to irrigate more frequently but also the ability to more readily maintain specific moisture deficits at a level below field capacity either for part or all of the irrigation season. Irrigating to maintain a specified root zone soil moisture deficit provides the opportunity for increased soil moisture storage from rainfall during the irrigation season.

1.2 Components of Drip Irrigation System

The various components involved in the design of a drip irrigation system include: water tank/water source, pipe fittings, pipes, air release valves.

The field unit systems consist of distribution system (main lines, sub-mains, distribution lines and infield system), valves (air release valves) and emitters.

Source of water

Sources of water for any irrigation system can be surface or ground water and this water can be abstracted from a river, lake, reservoir or spring (need to know elevation and pressure available at that point). (Benami et al, 1984).

Intake facilities

This refers to structures built at the abstraction point from the water source to the conveyance system. It may involve a pumping or gravity system depending on the nature of the place. (Phocaides, 2007).

Conveyance system

This involves the flow/ movement of water from the source to the field either through open channels as in the case with canals mostly suited for surface irrigation or closed conduits as in pipe system. For a proper conveyance system to occur a study of the area needs to be done checking into the topography and identifying highest points of the command area.

The conveyance system should be laid in such a way as to ensure water is delivered at the highest points of the command area. (Benami et al, 2004).

Mainlines

Mainlines are pipelines that are connected to the conveyance lines and are mostly buried in the ground. They are made from either PVC or steel material depending on the nature of the place where they are to be laid. Their sizes are determined by considering quantity of water flowing through the pipe, velocity required, ground elevation etc. (Burt and Styles, 2000)

Sub-Mains

This is a conduit majorly that carries water from the main-line to serve a particular area. Its design is similar to that of the lateral main lines and it may include pressure regulators, flow control valves, manual or automatic control valves and filters. It is observed that discharge decreases across the length of the sub-main line.
There are ranges for drip system diameters for sub-main lines and these are chosen based on discharge required. (Benami et al, 2000).

Distribution lines

They have a smaller diameter compared to the sub-main lines.
These are conduits that carry water from the distribution lines to the emitters/drippers.

Generally lateral sizes of between 10mm-20mm diameter PVC pipes with perforations at a distance equal to the spacing of crops.

Spacing of drippers to be fitted in these lines depends on planting distance along a row (which depends on type of crop chosen). (Phocaides, 2007).

Emitters
These are devices used to control the discharge of water from the lateral to the plants. They are usually spaced more than 1 metre apart with one or more emitters used for a single plant such as a tree. For row crops more closely spaced emitters may be used to wet a strip of soil. Many different emitter designs have been produced in recent years. The basis of design is to produce an emitter which will provide a specified constant discharge which does not vary much with pressure changes, and does not block easily. (Phocaides, 2007).

2.0 MATERIALS AND METHODS

2.1 Study Area
The study area was National Water Resources institute Kaduna, the coordinate is 10°34´55.51" N and 7°25´4.68" E, National water resources institute Kaduna is a parastatal of the Federal Ministry of Water Resources and sanitation. The Institute is located in Mando, Kaduna State. It was established in October 1979 to address the national needs in water resources training and is mainly on research, the institute is foremost institution for capacity building in the water resources sector of Nigeria.

2.2 Pipe Materials/ Characteristics
The network for this system is PVC pipes; all pipes in the drip irrigation system have been sized to match the flow rates and pressure losses in each section of the system.

- The steps carried out to achieve these are:
- The length and sizes of the sub mains are equal
- The height of the sub mains to the ground level are equal. They are 0.15 meters to the ground level
- All the elbow and tee joint connectors were connected at equal intervals
- The drippers were positioned on the distribution line at equal interval. Each dripper is 40cm from one another

2.2.1 Water Supply
When considering a drip irrigation system, it is important to have an adequate water supply for the irrigated area during a drought period. If the water source cannot supply enough water for the system to function efficiently during a drought period, then installing an irrigation system may not result in sufficient additional yield or crop quality. Based on this, a tank of storage capacity of 200 litres was chosen for this work. The study was carried out in National water resources Institute Kaduna Site analysis provided information essential for the proposed root zone irrigation design. Site factors considered in site selection were the soil type, the overall field area and topography (or changes in elevation), possible water sources (tank) and proximity to water sources, as well as quantities available for both seasonal and peak daily requirement.

2.2.2 Controls
The control elements used in this project are:

- Air controlled valve (½ inch)
- Air nozzles (4.98mm^3)
- Water controlled valve (½ inch)

2.2.3 Dripper Spacing
In drip irrigation system the number of emitters normally depend on the crop type and spacing. Dripping point must be placed close to the crop row with consideration to avoid damage during field operations (e.g., cultivation, hoeing and pruning)

Table 1: Various crops and spacing under Irrigation system (James, 2000)

CROPS	SPACING (CM)
COWPEA	20-25
TOMATO	40-50
PEPPER	45-60
ONION	5-7
OKRA	30-45
LETTUCE	15-30
CABBAGE	45-60

In this study the drippers spacing was constructed for tomato which is 0.5m
Space between each drip point = 0.5m
Number of Dripping point = 20 dripping points
Covered area = 2.6m by 1.2m = 31.2m2

2.2.4 Discharge Point Design

The discharge points of this system are of equal size drilled with 0.5mm drill bit. The advantages of this design over the conventional drip irrigation system are;

- The pipe network for this system is of lower cost
- The convectional irrigation system pipe has embedded emitter drippers while the system constructed in this study make use of air nozzles which are cheaper to construct for the control of the dripping rate.
-

2.2.5 Other Fittings

Various plastic fittings (tees, elbows, etc.) are used to join drip lines. To prevent water leakage at threaded joints (nipples, valves, etc.), all threads are wrapped with a couple of layers of Teflon tape prior to assembling.

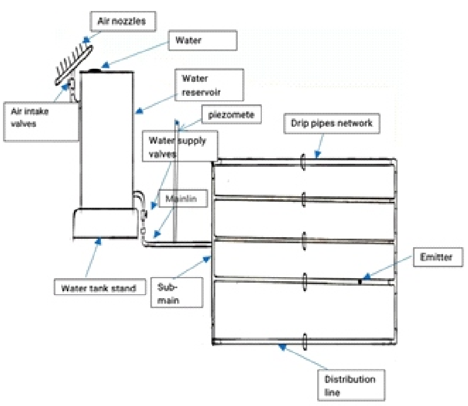


Figure 2.1: Schematic Diagram of Drip Irrigation System

2.3 Construction and Installation of Drip Irrigation System

A metallic tank of 200 litres was obtained and drilled at the top for the air intake valve and the base side for the water outlet to the drip system network. This drilling was obtained using drilling machine. After the drilling was carried out the next stage was the welding of the 1 inch socket respectively to the top and the base of the drilled part of the tank in order to ensure easy connection. The welded part was chipped to remove chipping and welded again to avoid leakages after which the welded parts were sealed with body filler to avoid leakage and prevent air passage.

The metallic tank was then painted for aesthetics, construction of the tank stand to ensure elevation. This was achieved by cutting angle iron of different lengths and welding them together to form a stand. The next phase was the cutting of the ½ inch pipes which are the parts of the drip line. The pipes were cut to various lengths using a hack saw and the drip points were drilled using the drilling machine with a 0.5mm drill bit. It was carefully drilled to avoid oversized bores or breaking of the drill bit. After all the 20 dripping points were made, the pipes were then threaded to ensure connections to form the drip system. After threading had taken place, pipes were all connected together using fittings like the Tee, elbow and union (for maintenance). Before the pipes were connected together, they were wrapped with thread tape to avoid leakage within the system. Caution was exercised to ensure that the thread tape wasn't applied in excess, if not it would cause leakage. Metal pipes and sheets were cut and welded together for the elevation of the drip system which prevents it from touching the ground surface which prevents blockage of the drilled points, before final connection, a piezometer was constructed using a giving set and measuring tape attached to metal bar.

Finally, an elbow was connected to the outlet part of the tank using a full threaded 1 inch pipe (external threading), which connects the socket and the elbow, then a ½ inch pipe was cut, threaded and applied thread tape in order to connect the gate valve and the elbow which was then connect to the drip system using a union, after a full threaded 1 inch pipe (external threading) was also used to connect the air release ball vale to the upper part of the tank.

2.4 System Flow Rate

- Height of the tank = 0.914m
- Diameter of the main line = 0.0127m
- Diameter of the sub main line = 0.0127m
- Diameter of the distribution lines = 0.0127m
- Capacity of the tank = 200 liters

The coefficient of velocity is 0.8 and the coefficient of contraction is 1.0 (Israelson, 1986.)

i.e cv = 0.8

cc = 1.0

Where;

CV = coefficient of velocity

CC = coefficient of contraction

The velocity of the fluid at the contraction is given by $v = \sqrt{2gh}$ (Ohio state university, 2016)

Where:

g = acceleration due to gravity (m/s^2)

h = height (m)

v = velocity (m/s)

$$v = cv \sqrt{2gh} \quad (1)$$

$$= 0.8 \times \sqrt{2 \times 9.81 \times 0.914}$$

V = 3.39m/sec

This value, 3.39m/sec is the velocity of the water from the contraction into the line.

From continuity equation.

$$Q = AV \quad (2)$$

Where:

Q = discharge m^3/sec

V = velocity of flow in m/sec

A = cross-section area in m^2

But $v = Cv \sqrt{2gh}$

Therefore $Q = Cv \sqrt{2gh} \times A$

Where:

$$A = \frac{\pi d2}{4}$$

And d = 0.0127m

Therefore A = (π x 0.0127^2)/4 = 1.27x10^{-4}

$$Q = Cv \sqrt{2gh \times A} \quad (3)$$

Thus, $Q = 0.8 \times \sqrt{2 \times 9.81 \times} 0.000127$

Q = 0.0399m^3/sec4.1

2.5 Determination of System Dripping Rate

The determination of system dripping rate in respect of the water requirement used in this study is tomato.

Water requirement for tomato is 5.6mm/per day (James, 2000)

The drip rates for the entire nozzle are shown below;

Time is constant = 15mins

Water requirement for tomato is 5.6mm/day

At nozzle 1 (average discharge is 0.14lit)

Average/ time = 0.14/15 = 0.093lit/min.

Water requirement/time in minutes = 5.6/0.093 = 582.16mins

At nozzle 2 (average discharge is 0.16lit)

Average/ time = 0.16/15 = 0.0106lit/min

Water requirement/time in minutes = 5.6/0.0106 = 528.30mins

At nozzle 3 (average discharge is 0.19lit)

Average/ time = 0.19/15 = 0.0126lit/min

Water requirement/time in minutes = 5.6/0.0126 = 444.44mins

At nozzle 4 (average discharge is 0.20lit)

Average/ time = 0.20/15 = 0.0133lit/min

Water requirement/time in minutes = 5.6/0.0133 = 421.05mins

At nozzle 5 (average discharge is 0.22lit)

Average/ time = 0.22/15 = 0.0146lit/min

Water requirement/time in minutes = 5.6/0.0146 = 383.56mins

At nozzle 6 (average discharge is 0.24lit)

Average/ time = 0.24/15 = 0.0160lit/min

Water requirement/time in minutes = 5.6/0.0160 = 337.25mins

At nozzle 7 (average discharge is 0.26lit)

Average/ time = 0.26/15 = 0.0173lit/min

Water requirement/time in minutes = 5.6/0.0173 = 323.69mins

At nozzle 8 (average discharge is 0.31lit)
Average/ time = 0.31/15 = 0.0206lit/min
Water requirement/time in minutes = 5.6/0.0206 = 271.84mins

2.6 Working Principle and System Description

This system is known to be air volume controlled irrigation system; the area covered by this drip irrigation system is 2.6m by 1.2m, with pipeline perforated with drill bit to make drip points, and a total of 20 dripping point. The distance between each drip point is 50cm, and distance between each drip line is 30cm as shown in Figure below.

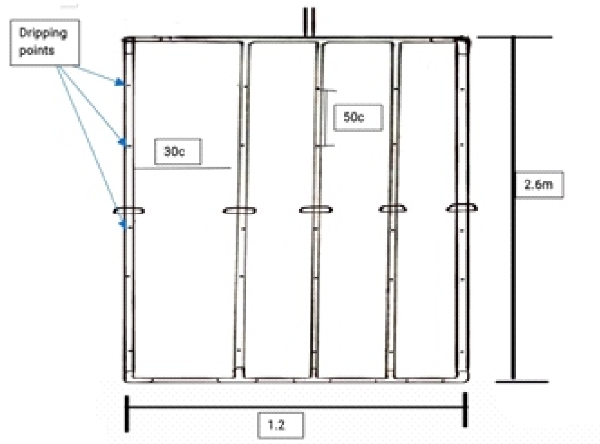


Figure 2 Drip Irrigation pipe networks

Water is being supplied from the tank which has an inlet and outlet. The inlet comprises of the control valves and air nozzles, this allow the regulation of the discharge of the drip. The rate at which water is been discharged depends on the volume of air that enter the water tank. So by controlling the air, the rate at which the system drip is directly proportional to the volume of air that get in to the tank through the air controlled valve. The tank has no other or available source of air except through the air nozzles.

2.7 Measurement of Discharge and Pressure

Measurement of discharge: The drip irrigation system was assembled on the site, after which the tank was filled with water. The control valve and air nozzles were opened allowing water to flow into the system, it was allowed to flow for a while. Collection vessels were placed under each dripping point to collect the discharge. The water collected was measured using the measuring cylinder.

Measurement of pressure: The drip irrigation system was assembled on the site, after which the tank was filled with water. The control valve was opened, and as the air nozzles were opened individually, air passes through it and forces the water to rise in the piezometer, which is recorded and used to calculate the pressure.

3 RESULTS AND DISCUSSIONS

3.1 Testing of Constructed Irrigation System

The following steps are the steps taking to determine the dripping rate of the constructed irrigation system.

Step 1: Assembling of the drip system accessories on site
Step 2: Filling the tank with water.
Step 3: Arrangement of collection vessels (Measuring cylinders) under drip point.
Step 4: Opening of pipe network water supply valve.
Step 5: Opening of air nozzles one after the other.
Step 6: Collection of water from drip point.
Step 7: Taking reading of volume of collected water.
Step 8: Tabulation, entering of data and calculations.

Figure 3 Testing of the system after construction

3.2 Water Analysis

Method of analysis: this parameters were measured using the E C meter. 3 samples of borehole water were collected. Irrigation water quality samples were analyzed by approved international and national standard methods for hydrogen ion concentration (pH), electrical conductivity (EC), total hardness (TH), total dissolved solids (TDS) and important cations such as calcium (Ca2+), magnesium (Mg2+), sodium (Na+), and SAR.

3.3 Soil Laboratory Analysis

The Soil samples were air-dried and sieved through a 2mm mesh and 0.42mm mesh respectively. Particle size analysis for the soil samples were carried out by hydrometer method using Sodium Hexameta Phosphate (Calgon) as the dispersant. Soil P^H in water and calcium chloride ($Cacl_2$) was determined in ratio of 1:2 using P^H meter ES20 model. Organic carbon (OC) was determined by the Walkey and Black method while Total Nitrogen (TN) was by Kjeldahl digestion method.

Table 3 Soil Salinity Conditions

Class	EC (mmhos/cm)	SAR	ESP	Typical soil structural condition
Normal	Below 4.0	Below 13	Below 15	Flocculated
Saline	Above 4.0	Below 13	Below 15	Flocculated
Sodic	Below 4.0	Above 13	Above 15	Dispersed
Saline – sodic	Above 4.0	Above 13	Above 15	Flocculated

Adapted from FAO 2006.

Table 2: Physical properties of soils related to primary particle size fractions

Physical Property	Relative impact of the fraction on the soil property			
	Coarse Sand	Fine Sand	Silt	
Water holding capacity	Very low	medium	High	Very high
Capillarity	Very low	Good	Great	Very great
Rate of water movement	Very fast	Fast	Slow	Very slow
Absorption capacity	Very slight	Slight	High	Very high
Cohesion and plasticity	None	Slight	High	Very high
Relative temperature	Warm	Fairly warm	Cold	Very cold
Aeration	Very good	Fairly good	Poor	Very poor

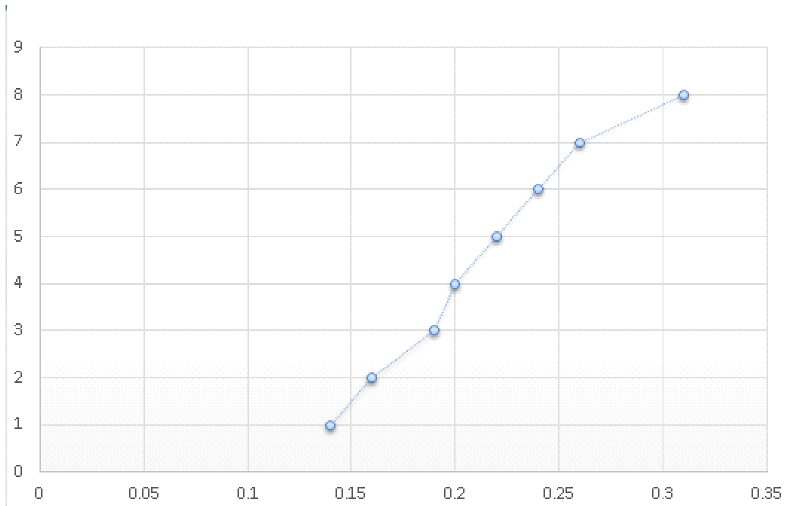
Adapted from FAO 2006.

3.4 Air Intake Irrigation System Performance.

The cumulative average discharge rates for the sampled laterals of drip irrigation system of study are shown in table 4.0. The emitter average discharge rate along the laterals of the drip irrigation system are as follows 0.14L, 0.16L, 0.19L, 0.20L, 0.22L, O.24L, 0.26L, and 0.31L respectively for an 15min interval duration. The variation of the discharge was recorded as follows, 0, 0.02, 0.03, 0.01, 0.02, 0.02, 0.02 and 0.05 respectively. Air intake demonstrated to have significant effect on the discharge rate of the drip system. The elevated value of mean emitter discharge is closely related to the quality of irrigation water and occurs as a result of multiple factors, including physical, biological and chemical agents. (Nasab, 2014). Other significant factors affecting emitter discharge include water temperature, quality with which the emitter is manufactured, according to James, (1993). The variations observed from emitter average discharge rates could be as a result of the difference in land slope as similar reports was presented by Raphael et al. (2018). As indicated by James (1993); and Raphael et al. (2018) the emitter discharge variation mainly depends on pressure differences owing to difference in operation head, water temperature, quality with which the emitter is manufactured.

Table 4: Discharge Rate at Different Air Intakes to the Water Tank.

Drippers/Nozzles Discharge (litres)	1	2	3	4	5	6	7	8
1	0.150	0.170	0.200	0.215	0.240	0.265	0.280	0.310
2	0.140	0.160	0.180	0.190	0.215	0.240	0.260	0.300
3	0.130	0.150	0.175	0.185	0.210	0.230	0.250	0.305
4	0.125	0.165	0.195	0.210	0.225	0.250	0.265	0.335
5	0.135	0.155	0.175	0.200	0.220	0.235	0.270	0.300
6	0.145	0.170	0.185	0.205	0.215	0.245	0.250	0.325
7	0.140	0.160	0.180	0.195	0.235	0.230	0.255	0.320
8	0.135	0.155	0.200	0.185	0.240	0.250	0.270	0.305
9	0.125	0.160	0.195	0.210	0.225	0.235	0.275	0.330
10	0.145	0.165	0.175	0.195	0.210	0.255	0.255	0.335
11	0.130	0.175	0.180	0.215	0.220	0.260	0.280	0.300
12	0.125	0.170	0.180	0.190	0.230	0.265	0.265	0.310
13	0.125	0.155	0.175	0.185	0.215	0.240	0.260	0.315
14	0.150	0.175	0.200	0.200	0.235	0.255	0.275	0.325
15	0.135	0.160	0.185	0.210	0.210	0.230	0.250	0.300
16	0.130	0.150	0.195	0.205	0.220	0.245	0.255	0.305
17	0.145	0.155	0.175	0.180	0.215	0.260	0.280	0.325
18	0.140	0.150	0.180	0.195	0.225	0.245	0.260	0.330
19	0.125	0.170	0.200	0.215	0.240	0.230	0.255	0.315
20	0.145	0.165	0.175	0.185	0.225	0.240	0.270	0.300
Total	2.72	3.24	3.71	3.97	4.47	4.91	5.28	6.29
Average	0.14	0.16	0.19	0.20	0.22	0.24	0.26	0.31
Variation	0	0.02	0.03	0.01	0.02	0.02	0.02	0.05



Average water discharge at drip points (Lit)

Figure 4: Air intake points to the water reservoir against the average discharge

3.5 Irrigation Water Quality

The physical and chemical characteristics of the untreated borehole used for the drip irrigation in the study are shown in Tables 4.2. All parameters were found to be below the level of concern. Turbidity as an indicator of water clogging potential was also found to be very low, the same with the level of Total Dissolved Solids. The source of water for the study met chemical standard para meters. Sedimentation and clogging is not likely to occur. These results also indicate that borehole water was safe for usage in crop cultivation and contained less dissolved substances value of which is very good as demonstrated in Akhtar et al. (2014),; FAO (2019). The pH is the concentration of hydrogen ions (H+) and hydroxyl ions (OH−) in the water. It is used to determine the acidic, basic or neutral behavior of water. The pH values for the irrigation water was found to be 6.40.

Table 5: Irrigation Water Physio-Chemical Analysis Results

Sample	Temp 0C	Na (Mg/l)	TDS (Mg/l)	EC (µS/cm)	TURB (NTU)	pH	SO_4 (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	Cl (Mg/l)	SAR (Mg/l)
1	24.4	6.474	39.7	79.3	1.4	6.1	5.0	3.21	1.0	22.0	0.5
2	24.2	6.454	41.6	83.2	1.5	6.2	10.0	2.40	1.2	17.5	0.6
3	24.2	6.511	39.3	78.7	1.5	6.1	5.0	2.40	1.6	25.0	0.6
Average	24.3	6.480	40.2	80.4	1.5	6.1	6.7	2.7	1.3	21.5	0.6

Table 6: FAO Standard Specifications for Irrigation Water Quality

Parameters	Units	Standard (FAO,2019)
PH		6.5-8.4
Na	Mg/l	0-9
TDS	Mg/l	35.45 –48
EC	us/cm	0-250
TEMP	(°c)	22-29.9
Turbidity	NTU	5.0
Calcium	Mg/l	0-120
Chloride	Mg/l	0-300
Magnesium	Mg/l	0-5
Sulphate	Mg/l	0-400
S.A.R	Mg/l	0-13

Water could be classified acidic water. The slightly acidic pH level of borehole water was not strong enough to prevent clogging especially after long accumulation of suspended solids and mineral precipitation even though it is suitable for agricultural uses FAO (2019). The pH of water and soil could not harm the plant growth directly. pH highly affects the efficiency of coagulation and flocculation process.

3.6 Soil Physiochemical Properties.

The results of the physiochemical properties analysis of the soil sampled from the study area as presented in Table 4.3. The soil of the study field was found to be loamy sand with an apparent specific gravity (bulk density) were 1.43 g/cm^3 at 10 cm depth of sampling, 1.39 g/cm^3 at 20 cm depth and 1.41 g/cm^3 at 30 cm depth. In this research, the core method was used in determining the dry bulk density of the collected soil samples. Several research findings have shown that, average soil bulk density for a cultivated loamy sand range between 1.1 g/cm^3 to 1.4 g/cm^3, USDA-NRCS (2018). The test conducted on porosity showed that, the soil porosities were 45.14%, 46.60% and 45.64% at 10 cm, 20 cm and 30 cm depth respectively.

Table 7: Textural Classification of the Soil under Irrigation

Parameter /Depth	0-10cm	10-20cm	20-30cm
% Sand	80.00	86.00	82.00
% Silt	10.00	7.00	18.00
% Clay	4.00	4.00	4.00
Texture.	Loamy Sand	Sand	Loamy Sand
B.D(g/cm^3)	1.43	1.39	1.41
% Porosity	45.14	46.60	45.64
% O.M	11.90	3.97	4.60
pH	6.9	7.7	7.8
% O.C	6.9	2.3	2.7
% T.N	O.60	0.20	0.3

With this percent of porosity, the soil had the ability to allow for better water movement through the soil along with better aeration for better plant root development. Essien & Essien (2014) argued that porosity is the total amount of pore space in the soil and the recommended porosity of soil for crop cultivation ranges from 30% and 60%. Porosity also affects the rate of movement of air and water. The soil from the study area is good for crop cultivation with an average of 45.79% porosity.

3.7 Discussion

The constructed drip irrigation set was tested and the result is shown on Table 4. This also shows that as different nozzles are opened, each nozzle can be used at different stage of plant growth. At the early stage of plant growth (tomato), water which may be required will be minimum; therefore nozzle 1 can be used which will be opened for 9hours to attained the water requirement needed per day which 5.6mm/day (Ohio State University, 2016) and as its growth increases other nozzles can be used to meet the water requirement.

Nozzle 1 has the emitter discharge rate of 0.093lit/min. which is the minimum emitter discharge. Nozzle 2 has emitter discharge rate of 0.0106lit/min, Nozzle 3 has emitter discharge rate of 0.0126lit/min, Nozzle 4 has emitter discharge rate of 0.0133lit/min, Nozzle 5 has emitter discharge rate of 0.0146lit/min, Nozzle 6 has emitter discharge rate of 0.0160lit/min, Nozzle 7 has emitter discharge rate of 0.0173lit/min and nozzle 8 has the max with the emitter discharge rate of 0.0206lit/min which is the maximum emitter discharge.

The graph in figure 4 shows the rate of discharge of drip irrigation system constructed for the project which is directly proportional to the volume of air that enter the irrigation system water reservoir.

Conclusion

High irrigation water distribution uniformity is essential for the drip-irrigation system to reduce water losses in fields and maximize farmer's returns. In this study, the performance of the drip-irrigation system was found significant for a 200Ltr overhead tank. The uniformity of water application was 80% indicating that the emitter is good The average discharge rates were 0.14l/h, 0.16l/h, 0.19l/h,0.20l/h, 0.22l/h, 0.24l/h, 0.26l/h and 0.31l/h respectively. The water distribution efficiencies at different air intakes are: 79.5%, 79.5%, 80%, 80% 79.5%, 79.5%, 79.5% and 79.5% respectively indicating good water application and was quite significant for the evaluation of the uniform distribution of water for the design. The constructed drip irrigation system in this project work has shown that drip pipe network can be used for different plant with similar water requirement and spacing, this will save the cost of changing pipe network each time there is changes in crop with similar water requirement and spacing.

In this research work the rate of discharge depends on the volume of air entering the system water tank. All the materials used in this construction are locally sourced materials.

The availability of drip irrigation system using local materials will greatly help to minimize the problem of high cost of initial investment which discourages the average farmer from involving in drip irrigation practices despite its numerous advantages, this irrigation method has many advantages and is easy to install. The expansion in rural communities could contribute to relevant water savings in most areas.

The system designed and constructed in this study may be used in same gardens (backyard farm).

Recommendation

1. It is recommended that water reservoir with thick wall is the best for the construction of this work.
2. It is best used on small gardens (backyard farm).
3. Can be tried on other crops with similar water requirement and spacing; and
4. For future work, additional research and analysis should be carried out so as to establish all the micro elements not analyzed in this work, and to know the actual volume of air that is entering the water tank when each air nozzle is open.

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