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Performance Evaluation of Improvised Drip Irrigation System

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ABSTRACT
Most farmers in developing countries hardly afford standard irrigation system equipment, they resort to buying poly vinyle chloride (PVC) pipes as improvised equipment in farms for irrigating vegetable crops. Performance and evaluation of improvised drip irrigation systems was carried out, using PVC, unplasticized polyvinyl chloride (UPVC) and infusion set materials. Soil properties of the experimental plot was analyzed. Medi-emitter calibration ranged from 0-35mm at 5mm intervals. Minimum and maximum flow occurred at 20 and 35mm, while at 15mm, water flow occurred in droplets. Flow rates from 15, 20, 25, 30 and 35mm gives $1.47x10^{-6}m^3/s$, $2.53x10^{-8}m^3/s$, $2.53x10^{-6}m^3/s$, $2.81x10^{-6}m^3/s$ and $3.85x10^{-6}m^3/s$ respectively. The improvised irrigation system was evaluated by raising cucumber vegetable crop of seventy days life span, and used 2063.502liters. The performance of the drip system was evaluated based on; length and thickness of tube, slip connector, drip chamber and spike thicknesses, slide clamp length, VPC pipes diameters, hydraulic parameters and crop yield. The agronomic performance of the crop yield was 95% yield. The was no significant effect on the efficiency and performance of the improvised drip system. It is recommended that the improvised drip irrigation system can be efficiently used for two to three years.

Key words: Improvised, Drip irrigation, Medi-emitter, Experimental, Cucumber crop.

1. INTRODUCTION

Irrigation is a mechanization tool that comes into play as one of the means of improving total volume or reliability of agricultural development by managing water for crop production [1]. World population currently growing at a rate of about 1.5% [2], is intensifying pressure on our natural resources especially water. The world trend in irrigation is such that the total irrigated area was 311 million hectares (ha) [3].

Globally agriculture makes use of available water accounting for about 70% of all uses. In places where agriculture is the main activity as in India and Africa, 90% of water is used for agriculture entailing use of irrigation. It has been found that because of temporal and spatial variations potential, usable water is small in supply [4,5]. Predictions showed that by the year 2025, about 35% of the world population may face water shortages [2]. This worrisome forecast has attracted concerted efforts to speedily institute potent water management policies that may prevent water scarcity in the future. Most recommended strategies to avert an impending water crisis emphasis increased efficiency from the irrigation sub-sector, and one way of achieving this, is for farmers to switch over from the traditional flooding method of irrigation to the highly efficient drip system. Regrettably, the cost of conventional drip systems deters their adoption by peasant farmers who command the agricultural sector of developing countries. Consequently, only about 1% of the total irrigated land world-wide is currently under drip irrigation [6].

In Nigeria, the agricultural sector accounts for nearly 15% of the GDP, yet agricultural productivity is on the decline while population increases. About 90% of the country's food is produced by small-scale farmers cultivating tiny plots of land who depend on rainfall than irrigation systems [7] (Annon, 2008); therefore, it is necessary that the agricultural sector be enhanced or promoted through introduction of certain technologies. The Government through Millennium Development Goals (MDGs) joined other UN countries to adopt proposition for irrigation as a means to improve food supply with the available water and a way to bring more land under cultivation [8].

Nigerian land mass is 92.4 million ha [9], out of which 82million ha is arable but only 34 million ha are utilized [10,11], and out of this between 4.0 to 4.5 million ha (approximately 4.5 to 5.0% of the land) are suitable for irrigated agriculture but only 1.1 million ha can be supported fully by the water available, the remaining 3.4 million ha are flood plains. Olden surface irrigation methods are still in use which results into water wastage resulting in low yield.

Recently, the concept of affordable Micro-irrigation systems has been identified as a commensurate drip technology for low-income farmers. These systems equally possess momentous potential for efficient agricultural water use. Considerable research has therefore been conducted in this domain with much success [12,13].

The pertinent predicament for the low-income farmers or subsistence farmers is that the irrigation systems equipment are not affordable, because they are expensive. In Nigeria, most farmers who engage in irrigation farming (mostly vegetable crops) using sprinkler or drip irrigation systems resort to buying poly vinyle chloride (PVC) pipes as improvised equipments because standard irrigation pipes are not affordable.

However, the uniformity and general performance of the PVC irrigation systems are affected by hydraulic design, calibration problems and emitter clogging among other factors.

The objective of this study was to set up a micro-irrigation system using PVC pipes with disposable infusion set (Medi-emitter) as part of components; calibrate and evaluate the performance of the system on cucumber vegetable crop and monitor the uniformity of hydraulic deliveries within the study period. Verify, if the environmental conditions affect the PVC pipes expansivity and medi-emitter dripping performance and evaluate the systems performance on the water requirement and yield on Cucumber vegetable crop.

2. MATERIALS AND METHODS

2.1 Study Area

Makurdi is the capital city of Benue state Nigeria. It lies between latitudes 7^0 45'and 7^0 52'N of the equator and longitude 8^0 35' and 8^0 41'E of Greenwich meridian, in the Northern Guinea Savannah agro-ecological zone, where river Benue passes through, referred to as Benue valley. The valley is highly agriculturally productive as home to highest producers of variety of crops such as cassava, soybean, guinea corn, yams, sesame, rice and groundnuts for the country [14]. However, no form of irrigation is ongoing in the area even with the available water resources (streams and river Benue tributaries).

The climate in Makurdi is referred to as a local steppe climate within the humid zone with little seasonal temperature variation throughout the year. Two major seasons do exist, the rainy season between April and October and the dry season between November and March [15]. The temperature averages 27.58°C while average annual rainfall is 690 mm. The least amount of rainfall occurs in March. The average in this month is 10 mm. The greatest amount of precipitation occurs in August and September, with an average of 260 mm and the temperatures are highest on average in March, at about 35.85°C with the lowest average temperatures occurring in January, with 26.6 °C [14].

2.1.1 Experimental site

The study was carried out in an experimental plot in the Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi, Benue State. Water was sourced from a 1000 litres tank to the farm through an installed water network systems.

2.2 Materials Used

The materials used for the study were classified into two parts; the materials used for land preparation, measurement, soil test, (Table 1) and those use for Irrigation and result recordings (Table 2).

2.2.1 Determination of site soil and hydro characteristics

Soil characteristics of the study site are directly influenced by relief, decomposition of parent material, climate, timing and organism. Loamy soils can encompass a variety of infiltration speed [16]. Therefore, predominant soil constituents and characteristics of the site soil were done to determined; Particle size distribution, the field capacity (FC) of the soil, Permanent wilting point (PWP), density, Available moisture content (percentage %), Moisture Content (%).

Hydro characteristics that affect irrigation systems were also determined in the areas of; Evapo-transpiration (consumptive use), Net Irrigation Requirement (NIR), Gross Irrigation Requirement (GIR), Irrigation interval/frequency, Irrigation interval (It), Irrigation period (Ip), Drip set capacity, Pressure variation of the system, Head losses computations and Linear calibration of the medi-emitter and amount of water applied.

2.2.2 Experimental set up

In irrigation design consideration [17], the mains, sub-mains and laterals pipes specifically design for drip irrigation withstands saline irrigation water and it is not easily affected by chemical fertilizers [18], but all the pipes use in the experiment and the improvised medi-emitters are made of PVC (poly vinyle chloride) materials, laid and couple according to standards [19-22]. The experimental plot was designed to cover an area of $16m^2$, with a systematic water conveyance layout for an efficient drip irrigation system study (Figure 1). The improvised medi-emitters [23] (Figure 2) were fixed into the pipes with specifications as shown in Table (2) and laid at each unit of the plant with the spike (water outlet) directly on each plant head (Plate 1). The Set up Farm Gravity Irrigation System was checked by determining the flow rate discharge from the emitters, measured and calculated using emission uniformity while the results were compared with micro irrigation uniformity classification standard based

Table -1 Materials Used for Land Preparation, Measurement and Soil Test

S/N	Materials	Uses
1	Vernier Caliper	Measures internal and external diameter of pipes line
2	Measuring Cylinder	Measures the volume of liquid (water).
3	Funnel	Guide/direct water into the graduated cylinder/Conical flask.
4	Soldering Iron	For perforations on the laterals PVC pipes
5	Soil Moisture Content Test Instruments	
	Weigh Scale	Obtain mass of soil samples
	Cans	Collect soil sample.
	Oven	Dry soil samples.
6	Bulk Density Test Instrument; Set of sieves, sieve shaker, weigh balance, brush, mortal/piston	Determine the soil's bulk density.
7	Evaporative pan	Carrying-out Evapo-transpiration test
8	Recordable Rain-gauge	Records rainfall amount in (mm)
9	Hack- saw	Cut PVC pipes into design sizes
10	Gum (PVC Solvent)	Joining PVC pipes
11	Improved Variety of Cucumber seeds	Used for Performance Analysis (study)

Table -2 Materials Used for Water Conveyance

Materials	Description	Uses
Water Tank	1000 Litres capacity	Store water used for Irrigation.
Main Line	2.54cm (1 inch) thickness of PVC pipes	Supplies water to the sub –mains from the tank (water source)
Sub-Main Lines	1.90cm (3/4 inch) thickness of PVC pipes	Connected to the Main and delivers water to the laterals
Laterals	1.27cm (1/2 inch) thickness of PVC pipes of 900cm in length.	Supplies water to the medi-emitter (DIS)
Couplers	Tees, sockets, elbows, stopper and end-caps; made of UPVC	Direct where pipes travel and how the flow of the water in the pipes travel.
Disposable Infusion Sets, (DIS)(medi-emitter)	Improvised material, made of Plastics	Emits water in droplets during Irrigation

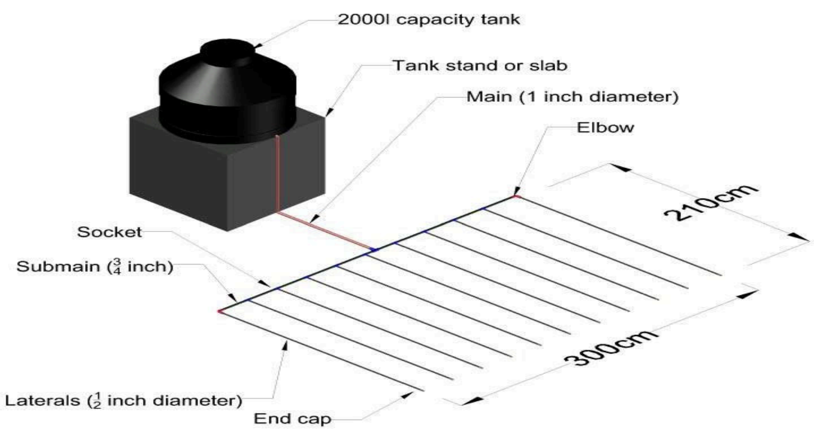

Fig. 1 Side View of Design Drip System set

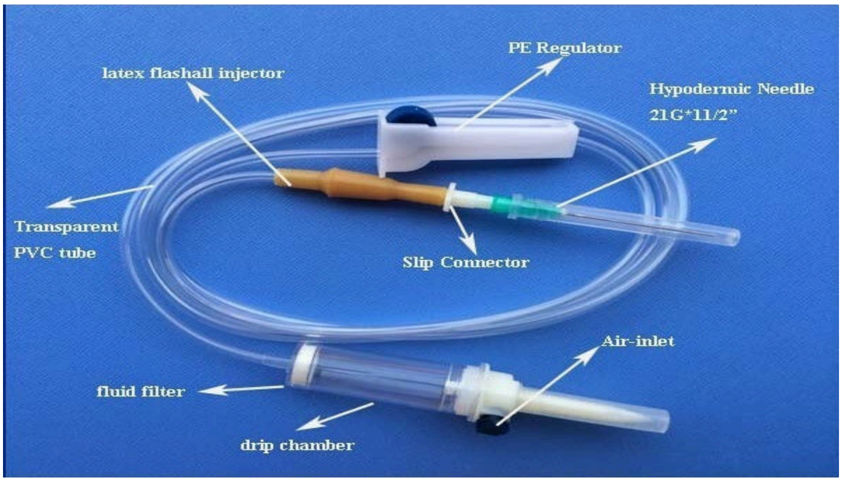

Fig. 2 Disposable Infusion Set, DIS (Medi-emitter). Source: Arshine.com. (2021)

Plate 1: Experimental Set-up of PVC pipes and Medi-emitters

on American Society of Agricultural Engineers [24-26], and the installation was followed by cultivation of Cucumber vegetable crop.

Crop consumptive use

The consumptive use of water at growth stage of crop and reference transpiration (ETo) [13], and determine using the relation:

ETo = K pan × E pan (1)

Where:

ETo : reference crop evapo-transpiration;

K pan: pan coefficient;

i. Net Irrigation Requirement (NIR): The net depth of irrigation was determined from readily available water (RAW).

RAW = (MAD) AW (2)

Where: RAW = Readily available water (mm), MAD = Maximum allowable deficiency,
AW = Available water.

$$RAW = \frac{(MAD)X(\,Drz)x\,(FC-PWP)X\,(P)}{100} \quad (3)$$

Where Drz = effecting rooting depth of cucumber, FC = Average field capacity (%)
Pwp = Permanent wilting point (%)

ii. Gross Irrigation Requirement (GIR): The gross irrigation requirement is the total amount of water applied throughout irrigation.

$$GIR = \frac{RAW}{FE} \quad (4)$$

Where;

GIR =Gross irrigation requirement

RAW (=NIR) = Net irrigation requirement and

FE =Field efficiency of the system.

iii. Irrigation interval/frequency. This is the number of days between irrigations during periods without rainfall

The design irrigation frequency = Net depth of irrigation/Transpiration rate of Cucumber vegetable crop.

$$T = Et \times \frac{Ps}{85} \quad (5)$$

Where, T = average transpiration rate of the water leaf (mm/day), Ps = area shaded by the crop as a percentage of the total area (%), ET = conventionally accepted consumptive use rate of the crop (mm/day).

iv. Irrigation period (Ip): Irrigation period is the number of days that can be allowed for applying irrigation to a given designed area during the peak consumptive use period of the crop irrigated [27].

$$Ip = \frac{(Mb-MI) X\ FC\ X\ bd)}{(100\ X\ Cu)} \quad (6)$$

Where: Ip = irrigation period (days), Mb = moisture content at the start of irrigation (%), and Ml = moisture content in the root zone at the lower limit of moisture depletion (%) FC and bd is bulk density. Cu = consumptive use (mm/day).

Area of Experimental Field = Length x Width (7)

For Experimental area, volume of water required (q) = Effective wetted area of experimental field x GIR. (8)

Actual irrigation periods maximum discharge per lateral line:

$$Q = \text{volume/time} = \frac{q}{t} \quad (9)$$

Where: Q = quantity of water discharge
q = discharge rate;
t = time taken to discharge the water

2.2.3 Crop planting and growth parametres of cucumber

Cucumber seeds were planted 2.5cm deep and 50cm apart between plants (spacing) [28], in a row and 40cm between furrows (Plate 2). Agronomic parametres of the cucumber vegetable crops were studied [29]. Plant height, nodes/internodes, number of leaves, leaf length, and width, as influenced by depth of water application at different growth stages were observed weekly throughout the study and recorded. Plant heights were measured from the soil surface to the highest point of the arch of the crop. The number of leaves was recorded every week as they unfurled up to the last stage of plant development. Leaf length and width, i.e major and minor diametres were taken on each crop sample at the various growth stages of the crop (Plate 2).

3. RESULTS AND DISCUSSION

3.1 Results

Soil properties of the experimental site were determined through laboratory standard methods and procedures. The soil properties of grain size/sieve analysis and soil moisture content were determined; while bulk density, soil texture, soil colour and soil structure are recorded in Table 3. The total amount of water taken up by crop for tissue building, transpiration or, unavoidable evaporation of soil moisture, (crop consumptive use of water by the cucumber crop) which is a reference of crop evapo-transpiration, was carried out and results were recorded in Table 4.

The average discharge rates of the sampled medi-emitters according to the valves and distances from the water source are presented in Table 5. The wetting depth ranged from 0.1m to 1.5m and the average wetting circumference was 60 cm. The 25 % discharge rates of all sampled medi-emitters was used to test the efficiency of emission (emission uniformity) of the ten control valves. Table (6) presents the average emission uniformity for the ten control valves calculated using the relations:

The infusion sets which served as emitters/drippers were calibrated linearly at different intervals of the flow regulator; the result is as shown in Table7. The performance evaluation of the improvised material for the drip irrigation PVC pipes of different sizes internal and external diameters were taken before and after use with a venier caliper, as well as average collated parameter of the on-field infusion set components lengths and diameters before and after use.

Useful data of the cucumber vegetable crop such as; growth stages, duration of cropping period and crop factor (K_C) value were evaluated. The usefulness of these data was used to plan the irrigation water schedule (Table 8 and 9). Each growth stages of the cucumber crop were monitored and reading of growth parametres was taken (Table 10) using recommended instruments. The performances of agronomic parametres of the cucumber vegetable crops are shown in Table 11.

Crop Development at week 2

Crop Development at Week 4

Crop at Mid-season (Flowering) Stage at Week 5

Fruiting Stage at Week 6

Crop at Late Season stage (Week 8)

Plate 2: Cucumber Vegetable Crop Monitored at Different Growth Stages and Harvested Fruit

Table -3 Results of Soil Physical Parametres

S/No	Parametres	Results
1	Soil Colour	Brown
2	Soil Structure	Blocky
3	Bulk Density	1.32g/cm^3
4	Moisture Content	6.57%
5	Soil Texture	Silty Clay Loam
6	Percentage of Soil Constituents	Sand 10% Silt 60% Clay 30%

Table -4 Evapo-transpiration Rate at the Experimental Site

Days	Time (pm)	Reading (mm)	Evaporation Rate (mm)
1st	2:45	105.52	-
2nd	2:45	99.08	6.44
3rd	2:44	95.21	3.87
4th	2:46	89.02	6.19
5th	2:34	85.35	3.67
6th	2:57	79.15	6.20
7th	2:40	73.87	5.28
8th	2:35	68.56	5.31
Average ET			5.28

Table -5 Discharge Rates (x10^{-8}) (m^3/s) of Sampled Medi-Emitters at 20mm Calibration.

Control Valves	1	2	3	4	5	6	7	8	9	10
Head Lateral (closest to water source)	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
Middle Lateral	2.53	2.53	2.50	2.53	2.51	2.50	2.53	2.52	2.53	2.53
End Lateral (farthest from the water source)	2.50	2.49	2.52	2.52	2.51	2.53	2.49	2.53	2.49	2.51

Table -6 Average Emission Uniformity (%) of the Medi-emitters from the Ten Control Valves

	Control Valves									
	1	2	3	4	5	6	7	8	9	10
Emission Uniformity (%)	79.7	84	86	89	86	86.4	89.6	83	85.7	83.2

Table -7 External and Internal Diametres of PVC Pipes before and after Use

	Initial Reading(mm)		Final Reading(mm)		Difference in Diametres(mm)		
Pipes	**Internal Diameter (D_1)**	**External Diameter (D_2)**	**Internal Diameter (D_3)**	**External Diameter (D_4)**	**Internal (D_3-D_1)**	**External (D_4-D_2)**	**Remark**
Main-line	28.93	32.23	29. 08	32.48	0.15	0.25	Negligible
Sub-main	21.64	25.28	22.92	25.40	1.28	0.12	Negligible
Laterals	16.49	20.09	16.60	20.32	0.11	0.23	Negligible

Table -8 Field Performance of Medi-Emitter (Disposable Infusion Set)

Components	Initial Reading(r_1)	Final Reading(r_2)	Difference (r_2-r_1)	Remark
Length of Tube	150cm	150.67cm	0.67cm	Elongated
Thickness of Tube	3.90mm	3.82mm	- 0.08mm	Contracted
Slip Connector Thickness	4.12mm	4.12mm	0.00mm	No Effect
Drip Chamber Thickness	15.60mm	15.30mm	- 0.30mm	Contracted
Spike Thickness	4.50mm	4.50mm	0.00mm	No Effect
Length of Slide Clamp	5cm	5cm	0.00cm	No Effect

Table -9 Crop Consumptive Use Data

Growth Stages	Duration of Growing Period (Days)	Crop Stage Analysis	K_C Value	Avg. ET_O (mm/day)	ET Crop (mm/day)	Area of Field (m^2)
Initial Stage	10	Planting	0.45	5.3	2.385	8.4
Crop Development	20	Crop Development	0.70	5.3	3.71	8.4
Mid-Season	20	Flowering and Fruit Setting	0.90	5.3	4.77	8.4
Late Season	12-20	Maturity and Harvest	0.75	5.3	3.975	8.4

Table -10 Irrigation Water Schedule

Growth Stages	Drip Efficiency	Vol. of Water(m^3)/day	Liters/day	Irrigation Duration	Irrigation Interval	Liters/growth stage
Crop Development	0.90	0.0280476	28.05	5hr 8min	Daily	560.952
Mid-Season	0.90	0.0360612	36.06	6hr 36min	Daily	721.224
Late Season	0.90	0.030051	30.05	5hr 30min	Daily	601.02

Table -11 Agronomic Performance of the Irrigated Crop

Week No.	Number of Leaves	Plant Height (cm)	Major Diameter (cm)	Minor Diameter (cm)	Internodes Distance (cm)	No of Fruit produce per Vine(x120)
1	2	2.69	4	1.56	0	0*
2	4	6.67	6	4.59	1.31	0*
3	7	21.3	9	6.49	5.33	0*
4	13	60.33	11	9.01	8.23	0*
5	25	95.17	15	12.38	9.51	0*
6	72	116.03	18	15.16	10.47	3
7	83	146.65	19	17.93	11.25	4*
Total						**480**
Mean						**4**

0* *crop were at growing stages;*

4* *Average number of fruits from week 6 was 3 fruits plus a fruit sprouted in week 7, totaling 4 fruits per vine.*

3.2 Discussion

3.2.1 Linear calibration of improvised emitter

The disposable infusion set (Medi-emitter) was calibrated at intervals of 5mm using the slide clamp of the infusion set and ranges from 0 –35 mm. Each graduation was calibrated such that their flow-rates were determined on the known length of the graduated flow regulator of disposable infusion set to obtain the discharge or flow rate (volume/time; m^3/sec) at each point (0, 5,10, 15, 20, 25, 30, 35; mm). Open channels have zero atmospheric (atm) pressure [30], therefore, the flow-rates of the infusion sets were calculated through a laboratory experiment using the open channel method, graduated cylinder, beaker and a stop-watch at each set of graduations (calibration).

There was no flow for 0, 5 and 10mm graduation; 35mm graduation had the maximum flow of 1000ml for 5 minutes, 56 seconds, while 15mm graduation flow occurred in droplets. However, since infiltration depends on soil types, the medi-emitters were set at 20mm graduation before installation and application on the field. The adopted graduation was to mitigate water losses that may occur through seepage.

3.2.2 Drip system evaluation

(a) PVC pipes

Pipes internal and external diametre readings were taken before installation and after utilization using a digital venier caliper (Table 7).

The differences in the internal and external diametres of main-line, sub-main line and laterals were found to be 0.15, 1.28 and 0.11mm for internal diameters and 0.25, 0.12, and 0.23mm for external diametres respectively. The expansions in the PVC pipes were insignificant. This inconsequential increment in pipes diameters did not affect the efficient use and performance of the drip system during irrigation.

(b) Crop consumptive use

The consumptive use of water by a crop is a function of the growth stage of crop and reference transpiration (ETo) [13]. An evapo-transpiration test was conducted to determine the evapo-transpiration rate (mm/day) for a period of one week. The calculated average was obtained:

K pan varies between 0.35 (humid low) and 0.85 (high humidity), Average K pan = 0.70.

The average wetting circumference of 60cm is large enough for production of leafy and vegetables [15].

ET_O of 5.28 mm/day was multiplied by crop factor value (K_C) for each stage of the crop as shown in the Table 11 above. These results were used to draw out an irrigation water schedule for the project as shown in Table 10.

MAD for leafy vegetables = 0.5[27;31- 32], with an effective rooting depth of cucumber (0.6 -1.5m) at 60 cm (Drz); P = area wetted as a percent of the total area = 40%. From equation (2),

$$RAW = \frac{0.5 \, x \, 0.6 \, x \, (11.7-3.7) x \, 40}{100} = 9.6 \text{ mm}$$

FE =Field efficiency of the system(equation 4), (For drip irrigation system, application efficiency = 80%)

$$= 9.6 \text{ mm x } \frac{80}{100} = 7.68 \text{ mm}$$

Irrigation interval/frequency (equation 5).

Taking Ps = 40 % and ET (Cucumber) = 5.3 mm/ day (from field ET Test),

T = 5.3x 40/85 = 2.49 ~ 2.5 (mm/day).

Therefore**,** Irrigation interval (It**)** = $\frac{9.6mm}{2.5mm}$ x /day = 3.84 $\simeq$ 4 days, which is the maximum irrigation interval that would not stress the Cucumber crop excessively.

Irrigation period (Ip): From equation (6);

Mb = 0.75, Ml = 0.625, For FC = 11.7%, dz = 600 mm, Cu =5.30 mm/day, bd = 1.32g/cm^3

$$Ip = \frac{(0.75-0.625) \, x \, 11.7 \, x \, 600 \, x \, 1.32)}{(100 \, x \, 5.30)} = 2.2 \simeq 2\text{days}$$

Area of Experimental Field (equation8) = Length = 4 m x 2.1 m = 8.2 m^2

Taking 40% of the entire experimental field area to be wetted by the medi-emitters, then the effective wetted area per head = wetted area (%) x Area of experimental field;

= 0.4 x 8.2 = 3.28m^2

For Experimental area, volume of water required (q) = Effective wetted area of experimental field x GIR (eqn 8):

= 3.28 x 0.012 = 0.03936 m^3

Volume of Water = Gross application depth x area = 39.36 $\simeq$ 40 liters

Various actual irrigation periods of 24hrs, 48hrs and 72hrs were tried after which 24hrs was chosen for the design because it gave maximum discharge per lateral line(equation 9).

$$Q = \text{volume/time} = \frac{q}{t} = \frac{0.03936(m^3)}{24(hrs)} = 0.00164m^3 = 1.64 \text{ l/hr}$$

q = 0.03936(m^3)/48 (hrs) = 0.00082 m^3/hrs = 0.82 l/hr

q = 0.03936(m^3)/72 (hrs) = 0.000547 m^3/hrs = 0.55 l/hr

For each lateral the discharge q = 0.000456 l/sec.

The 60 medi-emitters were spaced 35 cm along the lateral line. For 60 medi-emitters, the discharge rate,q = 1.64 l/hr

Therefore, for 1 medi-emitter = $\frac{1.64}{60}$ = 0.027 l/h
Each lateral line contains 6 medi-emitters with a total flow rate of 0.164 l/hr
Main line discharge rate = 1.64 l/hr x 10 = 16.4 l/hr
Drip set capacity: In this design, the area of the garden irrigated: 8.4 m^2 (4m x 2.1m).
Therefore, amount of water required per irrigation = area of the garden x gross irrigation depth = 4m x 2.1 x 9.6 = 400cm x 210cm x 0.96cm = 80,640cm^3 = 0.8064 x10^2 litres.

(c) Flow rates of Medi-emitter

Flow rates of medi-emitters were determined using laboratory equipments of 1000ml graduated transparent cylinder, cornical flask and a stop-watch. Based on volume quantification of water for the initial stage, 30.05ml of water was discharge at an average of 3 hours, 18 minutes. An average flow rate of 2.525 x 10^{-8} m^3/s was obtained by the medi-emitters, through-out irrigation period of cucumber vegetable crop.

(d) Discharge rates and emission uniformity

All the medi- emitters had approximately the same discharge rates. The little difference could be possibly due to pressure loss (head loss) as a result of distance from source of water. Variation recorded in the uniformity of emitter flow rate may have resulted from clogging, leakage or improper flushing, wearing of emitter components as they were adjusted several times in order to arrive at a desired flow rate in line with observations made[33]. This problem of clogging could be handled by periodic cleaning of filters, checking the pressure drop across the filter, checking the holes in the screens, and/or flushing the laterals at least two or three times a year [34-36].

Comparing the emission uniformity results obtained [25]with the standard values, shows that the values from this drip Irrigation system falls under good performance standard. This also proved the effectiveness of the system in water management and optimization when water is a limiting factor for crop production.

3.3 Cucumber Vegetable Crop

Forty (40) days specie of cucumber vegetable crop was cultivated within a life cycle of 70 days. Various growth stages of the crop were determined. This crop stages includes, the initial stage (10 days), the crop development stage (20 days), mid - season stage (20 days) and the late season stage to drying of leaves (20 days) [29].

A total of three hundred and twenty-two (322) cucumber fruits were harvested after maturity. The various stages are shown in the plate (10) above. The efficient and effective use of this improvised system resulted in the production of an average of four fruits per vine and a total of four-hundred and eighty (480) cucumber fruits were harvested from the experimental plot.

4. CONCLUSION

The improvised drip irrigation system and medi-emitter calibration achieved a high degree of uniformity of water application throughout the laterals as analyzed. The high water application uniformity shows that the variability among emitters used in this irrigation system is low. The efficiency was evaluated by raising cucumber vegetable crop on an experimental plot. The agronomic performance of the crop yielded an average of four fruits per vine which is equivalent to 95% yield of the fruits were harvested.

The technology is affordable, efficient, and durable. It will enable small-scale farmers to efficiently utilize marginal quantity of water, reduction of weed infestation and high cost of energy in lifting water from the wells or reservoirs for efficient irrigation of vegetable crops.

It is recommended that: The system be introduced for adaption by the small-scale farmers in Nigeria to enhance effective water conservation and management; infusion sets be set at graduation of 15 – 20 mm for efficient and effective use of water by crops, combat seepage and clogging problems that may occur from poor percolation or infiltration; infusion set can be used for more than one cropping season, because environmental conditions have little or no significant effects on its efficiency.

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