COMPARISON OF BIOSPHYSICAL PERFORMANCE OF CUCUMBER CROP UNDER DRIP AND SURFACE IRRIGATION IN HUMID CLIMATE

***Williams W. Akaamaa[1] and Malum, J. Flayin.[2]**
[1]Department of Agricultural and Bio-environmental Engineering, College of Agriculture, Science and Technology, Lafia, Nasarawa State, Nigeria,West Africa.
[2]Department of Agricultural and Environmental Engineering, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria, West Africa. +2348027299176

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ABSTRACT
In Nigeria, most farmers depend on rain fed crops while most of the vegetable crops that are needed all year round are raised through irrigation systems. Such crops as onions, pepper, carrots, cabbage, etc are said to be suitably raised by irrigation only in northern part of Nigeria having semi humid climate, hence don't perform well in the middle belt region with humid climates like Nasarawa state. An irrigational experiment was carried out to compare the biosphysical performance of a vegetable crop (cucumber-cucumissativas) using surface and drip irrigation, under Nasarawa South humid climate. Cucumber was planted in a rain fed plot and studied during raining season which served as control. Agronomic parametres of leaves (major and minor diameters), height and fruits produced were recorded and compared with the results from surface and drip irrigated plot during dry season. The drip irrigated crops produced 217 leaves followed by rain fed plot with 210 leaves and surface irrigated with 182 leaves. Rain fed plot had a mean height of 81cm followed by drip irrigated with 67.4cm and surfaced irrigated with 54.89cm. Fruit yield was highest in rain fed plot with 240 fruits at end of harvest, followed by drip irrigated plot with 192 fruits and surfaced irrigated plot with 144 fruits. From these results, it is recommended that some vegetable crops can perform and produce better through irrigation farming under humid climates of Nasarawa state.

Keywords: Climate, Vegetable, Cucumber, Irrigation, Surface, Drip, Biophysical.

1. INTRODUCTION
1.1 Background Study
General water availability is the most important factor limiting the development of agriculture in countries and regions with deficient water resources utilization like Nigeria. Efficient use of water for irrigation and irrigation scheduling is becoming increasingly very important for water management [1]. The competition for water resources is increasing dramatically nowadays, which requires improving water use efficiency that is possible under condition of protected structures; because irrigation systems have been under pressure to produce more with lower supplies of water[2]. Various innovative practices can gain an economic advantage while also reduces environmental burdens such as water abstraction, energy use, pollutants, etc. Farmers can also use technological systems already installed, adopt extra technologies, enhance their skills in soil and water management, narrow cropping patterns to lower water demand, usage and reduce agrochemical inputs[3].

In Nigeria, most farmers depend largely on rain-fed crop production, while most of the vegetable crops are believed to be suitable by irrigation do well only in northern part of the country and are therefore transported from there to other part of the country. Many opinions agreed that many of such crops have not been tried in the other part of the country to test their viability and favorable response to yield. Irrigation is the process of applying water artificially to the soil in order to ensure crop water requirement, ensure enough moisture for agricultural crop growth, provide crop insurance against short duration drought, reduce hazards of soil piping, soften the tillage pan (a dense compact layer), cool the soil and atmosphere to provide a good atmosphere for plant growth, and wash out or dilute harmful salts in the soil [4,5,6]. Agriculture is the greatest user of water resources in the world totaling 70% of total withdrawals and over 80% of the consumptive use of water[7]. At the regional variations, Africa utilizes 88% of water in agriculture to less than 50% in Europe [8]. Irrigated agriculture is the largest user of water resources in South Africa accounting for 53% of the total annual amount [9]. Nigeria agriculture accounts for 52% of water resources withdrawn annually [10]. In northern Nigeria where irrigation is opined to be most suitable falls under semi-arid region[11]; rainfall duration used to be short, this therefore underline the importance of irrigation in attaining crop production targets.

recommends Recent improvements in sensor technology, public weather-station networks, satellite and aerial imaging, wireless communications, and cloud computing, to solve many of the difficulties in using ET data and soil moisture sensors for irrigation scheduling of vegetables has been recommended[12.The Web and smartphone applications developed to automate many of the calculations involved in ET-based irrigation scheduling, soil moisture sensor data collected through wireless networks and accessed using web browser or smartphone apps. Energy balance methods of crop ET estimation, such as eddy covariance and Bowen ratio, are employed to provide research options for further developing and evaluating crop coefficient guidelines of vegetables, while recent advancements in surface renewal instrumentation have led to a relatively low-cost tool for monitoring crop water requirement in commercial farms. Remote sensing of crops using satellite, also provide useful tools for vegetable growers to evaluate crop development, plant stress, water consumption, and irrigation system performance.

1.1.1Earlier comparative studies

Small farm considering the use of drip irrigation should evaluate both the advantages and disadvantages of any of the adopted irrigation system to determine the benefits and efficiency on crops to be irrigated[13].

A study was carried on the effect of irrigation using five levels of pan evaporation replenishment at 20%,

40%, 60%, 80%, and 100% water supply on sandy loam soil in south Marmara region of Turkey to determined the marketable yield, irrigation water productivity (IWP), and economic return of tomato *(Lycopersicon esculentum)*, pepper (*Capsicum annuum)*, green bean *(Phaseolus vulgaris)*, and eggplant *(Solanum melongena)* under a drip irrigation method. The highest mean marketable yield of tomato (87.5 t ha-^{1}, pepper (59.2 t ha-^{1},green bean(7.6tha"), and eggplant (46.5 tha") was recorded at 100%, 100%, 80%, 100%, and 80% respectively. The IWP of tomato (23.6 kg nr"), pepper (16.5 kg nr"), green bean (2.6 kg nr"),

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and eggplant (13.6 kg nr") was the maximum at 80%, 80%, 40%, and 80% of pan evaporation replenishment, respectively. The result revealed that a further increase in irrigation amount resulting from 100% of pan evaporation replenishment did not increase the marketable yield of crops but reduced the IWP significantly. The net return increased with the increase in pan evaporation replenishment. The results revealed that the pepper is the most profitable crop, followed by tomato, eggplant, and green bean[14].

An Irrigation method had very significant influence on okra (Hibiscus esculentus) production,where Improvised Drip Irrigation System on Okra vegetablecrop was used in Nigeria.The results of statistical analysis revealed that there were significant differences on water application which reflected an increase in some agronomic parameters such as growth, weight, yield and vegetative development of the okra. The okra agronomic performance had a maximum fruit yield of 71.71% and water utilization efficiency of 55.49% of the total water applied[15].

2. MATERIALS AND METHOD

2.1 Study Area

Doma Dam is located in the South of Doma 6 km from Doma town, the Headquarters of Doma L.G.A of Nasarawa state of Nigeria and lies on latitude 9°3'N and longitude 9°32'E of the equator. It is about 20 km away from Lafia the capital of Nasarawa State. The Dam itself was constructed in 1985 by Lower Benue River Basin Development Authority (LBRBDA) with the aim of providing water for dry season farming (irrigation) and to supply Doma town and its environment with portable drinking water. As shown in Figure 1, the dam has its source from Kwarafin (Agatu) community where the stream was dammed downstream. The dam is surrounded by few hills and riparian vegetation.

The Dam is structured into 3 arms with each arm measuring over 2 km length and about 3 km wide. The Dam regulates the flows of the Ohina River in Nasarawa state. It is a multi-purpose dam with the primary purpose of irrigation and domestic water supply. The Dam is also proposed for domestic latent annual demand for power of about 19MW of installed capacity in addition to commercial and industrial demand [16]. This experiment was carried out at the Doma dam irrigation site (Figure 1).

2.2Experimental Set Up

The materials used for the research and their specifications for the drip and surface irrigation systems are as shown in Table (1).The experimental plots were laid out in two plots (1and 2). The layout was designed in such a way that plot 1 was irrigated using surface method, while plot 2 by drip so as to achieve the objective of the study.

Land Preparation and Planting: The experimental plot was prepared well enough by removing all weeds and then leveled to obtain a gentle slope. The plot was divided into two (plot 1 and 2). Plot (1) was prepared into a basin, while plot (2) was prepared into four (4) ridges. Planting of the cucumber seed was done manually at a spacing of 0.3 m to each other with a plant population of three seed per hole.

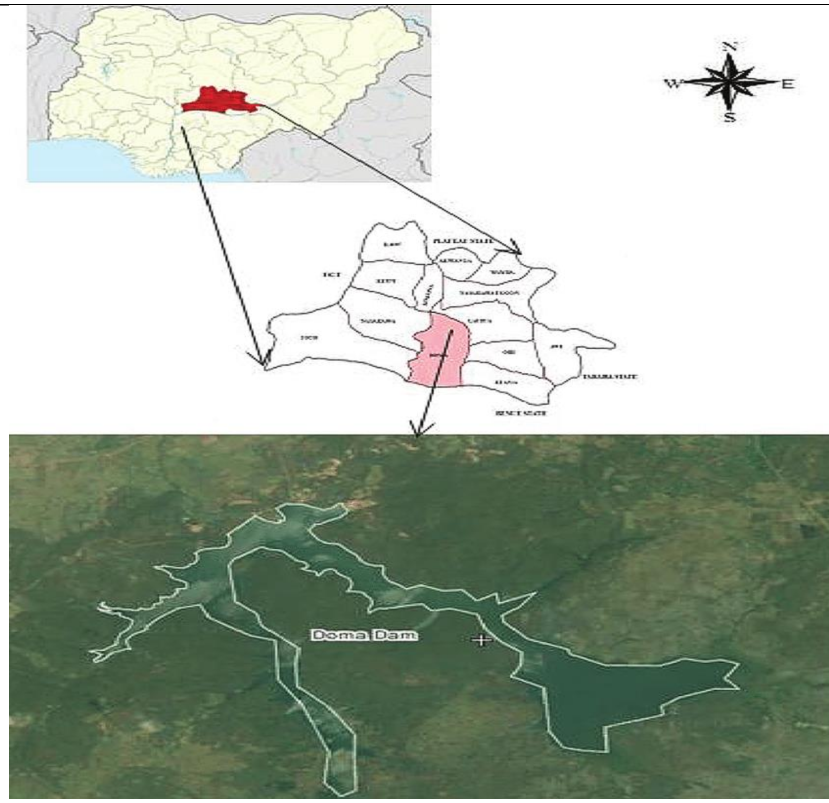

Figure 1: Map of Nasarawa State showing the Doma Local Government Area and survey area in Doma dam.

2.2.1 Irrigation water schedule

Both plots were scheduled and irrigated with water from same source. Basin irrigation was done for ten (10) minutes (these ten minutes irrigation was divided into 5 minutes regime, 5 minutes recession before completing with 5 minutes irrigation) every morning and evening at the initial stage of the crop development. This was reduced to only morning irrigation after the crop matured at week (7). Drip irrigation was done in the morning for two (2) hours at a rate of 0.58litre/m/day.

For surface irrigation: Area of irrigated Basin = Length * Breath(L*B)

The consumptive use of water at growth stage of crop and reference transpiration (ETo) [17], and determine using the relation:

ETo = K pan × E pan

Where:

ETo : reference crop evapo-transpiration; obtained from Evaporation test carried out on the experimental field.

Irrigation was carried out for 10 minutes schedule, amount of water applied at each stage of crop development was calculated using the relation:

Volume of water used = ETo (m/day) × Kc × Area

Where: Kc = crop factor

flow rate (Q) $= \frac{Volume}{time}$

Table 1: Materials / Specification used in Surface and Drip Irrigation Plots

Component/ Parameter	Specification
Surface Irrigation	
Row to row Spacing	35cm
Ridge depth	6.5cm
Irrigation duration	10 minutes
Plant per row	6
Drip Irrigation	
Area coverage	12 m by 12 m
Main Lines	2.54cm PVC pipe
Sub Main Lines	1.9cm PVC pipe
Lateral	1.27cm PVC pipe
Lateral Spacing	35cm
Emitters	Improvised Medi-emitter
Number of Emitters per row	3
Minimum spacing for Emitter	30 cm
Valves	3
Row to row spacing	35 cm
Ridge depth	6.5 cm
Irrigation Interval	Every 2 days
Irrigation time for drip	2hrs

For Drip Irrigation:

Crop consumptive use = ETo× Kc

where Kc = Crop factor; (varies with crop stages)

2.2.2 Crop Parameters Monitored

The crop data collected and recorded during the conduct of the experiment were:

Determination of Soil Moisture Content: The soil of the study area was subjected to moisture content test to determine the amount of moisture that could be retained during irrigation recess if the crop could withstand the irrigation interval of every two days irrigation. Soil samples were taken randomly from 3 sites and replicated 3times within the plot.

Evapo-transpiration: Evapo-transpiration of the study area was done using an installed Evaporation pan. It was filled with water every morning and by afternoon readings were taken to determine the possible eva-transpiration that occurred daily in the course of the study.

Plant Height: Plants heights (cm), leave length (cm) and leave width(cm) selected at random every week from each plot row, measured and recorded to obtain the weekly plant height from vegetative stage to harvest.

Leaf Surface Area: Leaves were randomly selected from some selected plant stand in each plot and their mean was recorded to give the weekly leaf surface area from vegetative stage to maturity (Plate 1).

Crop Yield: The crop has a life span of seven to eight weeks. Its start flowering and produces fruits at the sixth and seventh week, hence the biophysical agronomic performance was monitored from both surface and drip irrigation (plate 1 and 2).

3. RESULTS AND DISCUSSION

3.1 Results

Before the experiment was carried out, 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 2. The Soil moisture content (SMC) also referred to as Available Soil moisture (ASM) of the study area was investigated (Table 3). The soil of the study area was subjected to moisture content test by taking samples randomly from 3 sites and replicated 3times. to determine the amount of moisture that could be retained during irrigation recess if the crop could withstand the irrigation interval of every two days irrigation. The performances of the irrigated water on both surfaced and drip irrigation plots, flow rate and volume of water used were computed and results are shown in Tables 4 and 5.

Plate 1 a: Surface Irrigated Plot

Plate 1 b: Drip Irrigated Plot

Plate 1: Crop Growth at Fourth Week

Plate a: Some Harvested fruit from drip Irrigated Plot

Plate2 b: Some Harvested fruits from surface Irrigated plot

Plate 2: Fruit Yield from both Surface and Drip Irrigated Plots

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Table 2: Results of Soil Physical Parametres

S/No	Parametres	Results
1	Soil Colour	Brown
2	Soil Structure	Blocky
3	Bulk Density	1.27g/cm^3
4	Moisture Content	6.50%
5	Soil Texture	Silty Clay Loam
6	Percentage of Soil Constituents	Sand 12%
		Silt 60%
		Clay 28%

Table 3: Soil Moisture Content (SMC) of the study Area.

Replicates	M_1(g)	M_2(g)	M_3(g)	$M_2 - M_3$(g)	$M_3 - M_1$(g)	$(M_2M_3)/(M_3M_1)*100\%$
A1	62.6	292.4	277.7	14.7	215.1	6.83
A2	16.5	124.8	117.8	7	101.3	6.91
A3	63.3	284.0	268.8	15.2	205.5	7.40
B1	63.6	278.6	267.6	11	204	5.39
B2	62.1	287.5	275.5	12	213.4	5.62
B3	62.5	257.0	246.5	10.5	184	5.71
C1	61.5	302.3	285.9	16.4	224.4	7.31
C2	61.5	263.3	250.2	13.1	188.7	6.94
C3	16.9	146.1	137.6	8.5	120.7	7.04
Mean SMC						**6.57%**

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Table 4: **Computed Flow Rate of Water in Surface Irrigated Plot**

Crop stages	Crop Growth	Kc(crop Factor value)	ETo (m/day)	Area m	Volume of water used(L/day)
(Week1)	Planting	0.45	5.28×10^{-3}	2.88	6.84
(week 2-3)	Crop development	0.70	5.28×10^{-3}	2.88	10.6
(Week4-5)	Flowering/fruiting	0.90	5.28×10^{-3}	2.88	13.6
(Week6-7)	Maturity/harvest	0.75	5.28×10^{-3}	2.88	11.4

Table 5: **Computed Flow Rate of water in Drip Irrigated Plot**

Crop stage	Crop Growth	Kc(crop factor value)	ETo×Kc	Area m	Volume (L/day)
(Week 1)	Planting	0.45	2.376	3.36	7.2
(Week 2-3)	Crop development	0.70	3.696	3.36	11.2
(Week 4-5)	Flowering/fruiting	0.90	4.752	3.36	14.4
(Week 6-7)	Maturity/harvest	0.75	3.96	3.36	12

Agronomic parameters of number of leaves, plant height, major and minor diameters of the leaves and fruits produced were measured for both surface and drip irrigations, respectively on a weekly basis and compared with the result obtained from the control experiment (Rain-fed Cucumber cultivation) done during raining season (Table 6 and 7). All the biophysical parameters in surface and drip irrigation plots were measured and recorded. The mean biophysical performance of Cucumber crop on surface and drip irrigation plots were collated and the results are tabulated as shown in Tables (8 and 9).

Table 6: Cucumber Vegetable Crop Data (Experiment during Rainy season).

Week	Dates of Rainfall	Rainfall Amount (mm)	Remarks
1	24th- 28th July	0	No germination
2	29th July - 4th August	48.7	Viable seeds germinated
3	5th- 11th August	15	Plant parameters increases
4	12th- 18th August	24	Insect Infestation. Crop starts creeping
5	19th-25th August	11.5	Crop starts Flowering
6	26thAug-1st Sep.	73.8	Crop starts Fruiting
7	2nd-8th September	30.1	Fruits ready (matured)for Harvest.
8	9th-15th September	10.9	Fruit increase in thickness and Length.
9	16th-22nd September	13.2	Fruit appear Pale yellow
10	23rd-29th September	21.35	Crop leaves dry up gradually

Table 7: Mean Crop Parameters Performance from Rain Fed Experiment

Week No.	No. of Leaves	Plant Height (cm)	Major Diameter (cm)	Minor Diameter (cm)	No. of Fruits Produce per vine(x48)stands
1	-	-	-	-	*
2	3	6	5.8	3	*
3	10	15	8	6	*
4	12	55	11	9	*
5	25	90	15	12	*
6	75	170	18	15	4
7	85	230	19	18	5*

Total	**210**	**566**	**77**	**63**	**240**
Mean	**30**	**81**	**11**	**9**	**5**

* Not applicable because crops were at growing stages

5* A single fresh fruit sprout out adding to the 4 in week 6 to make 5fruits in week 7.

Table 8: Mean Biophysical Performance of Cucumber Crop on Surface Irrigation Plot

Week No	No.of Leaves	Plant Height (cm)	Major Diameter (cm)	Minor Diameter (cm)	Internodes Distance(cm)	No. of fruits produces/ vine (x48)
1	2	1.92	2	1.20	0	*
2	4	2.60	4	3.8	1.2	*
3	6	18.52	6	5.2	4.8	*
4	10	40.0	11	8.75	7.2	*
5	16	85.7	13	10.5	9.1	*
6	68	106.4	18	14.5	10.3	2
7	76	128.50	19	16.78	10.90	3*
Total	**182**	**384**	**73**	**60.73**	**43.5**	**144**
Mean	**26**	**54.89**	**10.4**	**8.68**	**6.2**	**3**

Not applicable because crops were at growing stages

3*A single fresh fruit sprout out adding to the 2 in week 6 to make 3 fruits in week 7

Table9: Mean Biophysical Performance of Cucumber Crop on Drip Irrigation Plot

Week No	No.of Leaves	Plant Height (cm)	Major Diameter (cm)	Minor Diameter (cm)	Internodes Distance(cm)	No. of fruits produces/ vine (x48)
1	2	2.67	4	1.54	0	*
2	4	7.0	6	5.3	1.4	*
3	8	23.2	10	6.8	6.0	*

4	15	66.0	13	10.0	9.1	*
5	27	100.2	16	13.6	10.45	*
6	76	122.5	20	16.4	11.2	3
7	85	150.0	21	18.38	11.51	4*
Total	**217**	**471.6**	**90**	**72**	**49.7**	**192**
Mean	**31**	**67.4**	**12.9**	**10.3**	**7.1**	**4**

*Not applicable because crops were at growing stages

4*A single fresh fruit sprout out adding to the 3 in week 6 to make 4fruits in week 7

3.2 Discussion

3.2.1 Irrigation water/ crop consumptive use

The surface irrigated area was studiedbased on the Area of basin using equation (1) as;

Basin Area = 180 × 160 cm (1.8 × 1.6)m^2 = 2.88m^2

ETo (From Evaporation test carried out on the experimental field) = 5.28mm/day

ETo = 5.28 × 10^{-3}m/day

Kc values are obtained from literature (Table 4)

ETo… From Evaporation test carried out on the experimental field

Irrigation was carried out in 10 minutes, therefore 60seconds =1minute

Then 10min = 600 seconds.

Amount of water applied at each stage of crop development

Vol of water used was computed from equation (3) and flow rate using equation(4).

Vol. = 5.28 × $10^{-3} m^3/day$ × 0.45 x 2.88 = 6.84 (L /day)

flow rate = $\frac{Volume}{time}$ = $\frac{6.84\times10^{-3}}{600}$ = 1.14 × $10^{-5} m^3/sec$ × 1000 = 0.0114 L/sec

Week (2-3) Crop development = 5.28 × 10^{-3} m/day × 0.70 ×2.88 = 0.01064448m^3/day ×1000 = 10.64448 (L/day)

Crop development Flow-rate =$\frac{volume}{time}$ = $\frac{10.64448}{600}$ = 0.0177408 L/sec

Week (4-5) = 5.28 × 10^{-3}m/day × 0.90 × 2.88 = 0.01368576m^3/day × 1000 = 13.68576(L/day)

Flow-rate =$\frac{volume}{time}$ = $\frac{13.68576}{600}$ = 0.0228096 L/sec

Week (6-7) = 5.28 × 10^{-3}m/day × 0.75 × 2.88 = 0.0114048m^3/day × 1000 = 11.4048(L/day)

Flow-rate = $\frac{volume}{time}$ = $\frac{11.4048}{600}$ = 0.019008 L/sec (Table 4).

For drip Irrigation irrigated plot, crop consumptive use was computed from equation (3). Crop factor(Kc) varies with crop stages (Table 5), Evapotranspiration carried out in field as ETo was 5.28 ≈ 5.3mm/day,

ETo=5.3mm/day, Area = L×B = 2.1 × 1.6 = 3.36 m^2

$$volume = Area \times (\frac{5.3\ mm/day}{1000}) \times 0.90$$

Initial week = 3.36 × 2.376/ 1000 = 0.00798m x0.90 = 7.182x$10^{-3}$$m^3$/dayx1000 = 7.2 L/day

(week 2-3) Crop development =3.36 × $\frac{3.696}{1000}$ = 0.01242x0.90 = 1.177x$10^{-3}$$m^3$/day × 1000 = 11.176 ≃ 11.2 L/day

Mid-season = 3.36 × $\frac{4.752}{1000}$ = 0.015967x 0.90 = 0.014370048m^3/day × 1000 = 14.370048 ≃ 14.4L/day

Late season = 3.36 × 3.96/1000 = 0.0133056x 0.90=0.01197504m^3 x 1000= 11.97504 ≃12 L/day (Table 5).

The performance of the crops under consideration was evaluated using agronomic parameters of number of leaves, plant height, major and minor diametres of the leaves and fruits produced. The performances of the irrigated crops were compared with the performance of the rain fed experimental plot done earlier during the rainy season because the crops were exposed to the required natural environmental conditions.

3.2.2 Effect of irrigation on growth/ height of plants

Forty (40) days specie of cucumber vegetable crop was cultivated. Various growth stages of the crop were determined. This crop stages includes, the initial stage, the crop development stage , mid - season stage and the late season stage to drying of leaves [18].

Development and Growth of Leaves: Generally, the development and growing number of leaves showed a continues increase from first week of planting to the end of the life span of the crop (week 7). The rain-fed plot leaves ranged from (0) in week (1) to 85 leaves at the end of week 7, giving a total of 210 leaves (Table 7). In irrigated plots; the surface irrigated plot started with sprouting of two leaves in week (1) and ended with 76 leaves in week 7.The total leaves from the plot was 182 (Table 8). Leaves from drip irrigated plot equally started with 2 leaves in week (1) and ended with 85 (same as surface irrigated plot) but the total number of leaves produced were 217(Table 9). The three plots had a weekly average rate of leaves production as 30 for rain fed plot, 26 for surface irrigated plot and 31 for drip irrigated plot (Tables 7, 8 and 9).

However, in the rain fed plot, there was a delay in the germination of seed by the first week because leaves or germination occurred by second week after planting. This might have been caused by the presence of moisture in the soil because the experiment was done in July - August- the peak of rainy season in the study area (Doma dam agricultural land area). Excess moisture in a soil cools the soils and might have lowered the required heat necessary as one of the conditions for seed germination[19].

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The major and minor diameters of leaves from the three plots indicated drip irrigated plot had the most developed leaves with a mean major diameter of 12.9cm and minor diameter of 10.3cm, followed by rain fed plot with a major diameter of 11cm and minor diameter of 9cm, while surface irrigated plot had the lowest leaves development of 10.4cm major diameter and 8.68cm minor diameter respectively. Practically, it was observed by finger feeling that the moisture in drip irrigated plot soils had more moisture than the surface irrigated plot soils. Therefore the drip irrigated plot retained more moisture content in the soil, hence crops had more water suction than the crops in surface irrigated plot. Rain-fed plot which was equally exposed to the effect of evapo-transpiration had less moisture content like that of the surface irrigated plot.

Crop performance by height: Height of plant in each plot was measured by using a meter tape. There was a progressive plant growth in all the blocks and the plant's heights continued to increase up to the last week of the plant life span (week 7), after which the crops began to wither. Despite the delay in germination on rain fed plot by one week, the height progresses rapidly from second week with 6cm height to 230cm by week 7, giving a weekly total of 566cm. In irrigated plots; surface irrigated plot measured 1.92 cm in week (1) and the 7^{th} week 128.5cm giving a weekly total of 384cm (Table 8).The growth in drip irrigated plot started with 2.67 cm in week (1) and progresses to 150cm by week (7)(Table 9).

By comparison, the rain-fed plot had the highest plant height of 230cm at week 7, followed by drip irrigated plot with a height of 150cm and thirdly, surface irrigated plot with plant height of 128.5cm.

The low rate of crop height in surface irrigated plot most have been caused by high evapo-transpiration caused by the environmental heat which was at its peak (February- March) in the study area (Doma dam agricultural land area). The drip irrigated plot maintained moisture because water was supplied to the base of the crop directly at root level while crop leaves provided cover for better conservation of more moisture, hence the crop grow better than the surface irrigated plot. The three plots had a weekly average height of 81cm for rain-fed plot, 55.89cm for surface irrigated plot and 67.4cm for drip irrigated plot. (Tables, 7, 8 and 9).

Fruit yield in irrigated plots: Cucumber as a vegetable crop by nature starts flowering by fifth week, produce fruits by the sixth week and matures at the seventh week. In the rain-fed plot which is regarded as a control plot, there were 48 plant heads (vines), each vine produced either 4 or 5 fruits per life span. The total fruits harvested from the plot were 240, giving an average of 5 fruits per vine (Table 7).

In irrigated plots, same 48 plant head per plot were maintained. Surface irrigated plot produced 2 or 3 fruits per vine, at the end of the season (experiment), 144 fruits were harvested giving an average of 3 fruits per vine (Table 8). In drip irrigated plot, the 48 plant head produced 3 or 4 fruits per vine and a total of 192 fruits were harvested at the end of the experiment(Table 9).

Analytically, all the biophysical parameters studied in this experiment performed better on the average. And from the results of the crop performance, it can be said that crops in drip irrigated plot achieve maximal crop performance, especially in the area of vegetable production and fruit yield.

4. CONCLUSION

From the study carried out, it was found that drip irrigation performed better in all the crop agronomic parameters (number of leaves, leaves diameter, plant height development) when compared with even the rain-fed plot. The fruit yield was highly recorded from rain-fed plot regarded as the control plot; but between the irrigated plots of surface and drip, the fruit yield from drip irrigated plot was higher than that of surface irrigated plot.

The environmental conditions for rain fed plot were favorable for fruit yield because it was during rainy season where there was less intensity of heat that influences excessive evapo-transpiration. In the irrigated plots which was done during dry season it was affected by excessive environmental conditions and that resulted into lesser production of fruits in the irrigated plots compared to the rain fed plot, where fruit yield harvested from rain-fed were (240), surface irrigated (144) and (192) fruits from drip irrigated plots.

However, as far as vegetable farming is concerned, it is a crop that is required throughout the year hence, irrigation farming by this experimental work has proven that some of these vegetable crops can be grown in the humid areas like Doma dam agricultural land area (the study area), by irrigation instead of relying on supplies from Jos- northern Nigeria, where it is believed as the only place with suitable environmental conditions to irrigate such vegetable crops in Nigeria.Base on the field experiment carried out, it is recommendations that:

- The method of irrigation used affect the yield of crops significantly, therefore suitable type of irrigation method (drip irrigation) should be adopted by farmers to obtain high yield.
- Since standard irrigation equipment are very expensive, government should encourage farmer by improvising affordable irrigation water sources through canals, boreholes, shallow wells, tube-wells etc, for farmers to carry out meaningful agricultural practices through irrigation to supplement crop production instead of depending largely on a single (rainy) season for crop production .
- Improvised irrigation equipment that could be tested in the process of the irrigation on many vegetable crop species as possible so as to make adequate data available for further researches.
- Locally identified available materials should be tested for the construction and installation of irrigation system to reduce the cost implication of initial investment.

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