



# **Effect of Water Stress on Crop Yield and Water Productivity of Drip-irrigated Pepper (*Capsicum* Spp.) in Southwest Nigeria**

**Samuel D. Oluwagbayide<sup>1\*</sup>, Muyiwa A. Okusanya<sup>1</sup>, Anthony A. Amori<sup>1,2</sup> and Joshua O. Akintade<sup>1</sup>**

<sup>1</sup>Department of Agricultural and Bio-environmental Engineering, Federal Polytechnic, P.M.B. 50, Ilaro, Ogun State, Nigeria.

<sup>2</sup>Department of Agronomy and Horticulture, University of Nebraska-Lincoln, United States.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author SDO designed the concept of entire project and wrote the first draft of the manuscript which was read through by all authors. Author MAO carried out the soil analysis of the experimental plot and supervised the irrigation scheduling aspect of the work. Author AAA handled all the statistical analysis and interpretation on the data.*

*Author JOA prepared the experimental plot, planted the pepper crop, carried out all the cultural practices and determined all the growth and yield parameters under the supervision of author SDO. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/JEAI/2020/v42i830579

Editor(s):

(1) Dr. Daniele De Wrachien, University of Milan, Italy.

Reviewers:

(1) Charu Shahi, Kumaun University, India.

(2) Manoj Kanti Debnath, Uttar Banga Krishi Viswavidyalaya (UBKV), India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/61423>

**Original Research Article**

**Received 25 July 2020**

**Accepted 01 October 2020**

**Published 20 October 2020**

## **ABSTRACT**

This research presents the effects of water stress on crop yield and water productivity of two local varieties of pepper (*Capsicum spp.*) under various drip irrigation regimes in Southwest Nigeria.

**Study Design:** The study was conducted during the 2018 and 2019 cropping seasons at the Teaching and Research Farm of Agricultural and Bio-Environmental Engineering of Federal Polytechnic, Ilaro, Nigeria.

The experiment was a 2 x 4 factorial experiments arranged in a randomized complete block design (RCBD) with two varieties of pepper (*Capsicum chinense* and *Capsicum frutescens*) and four drip irrigation regimes: 100%, 75%, 50% and 25% of actual crop evapotranspiration (ET<sub>100, 75, 50, 25</sub>) and

\*Corresponding author: E-mail: [samuel.oluwagbayide@federalpolyilaro.edu.ng](mailto:samuel.oluwagbayide@federalpolyilaro.edu.ng);

replicated four times. The experiment was repeated in the second year late season. Water was applied from 3 weeks after transplanting (WAT) after which growth parameters, crop water productivity and crop yield were monitored and subjected to statistical analyses.

The water productivity, crop yield and other crop growth parameters such as plant height, number of leaves, fruit length and weight were higher during the two seasons for the two pepper varieties under ET<sub>100</sub> and ET<sub>75</sub> irrigation regimes compared with ET<sub>50</sub> and ET<sub>25</sub> respectively. A significant difference ( $p < 0.05$ ) was observed in the growth parameters in all the treatments. However, there was no significant difference ( $p > 0.05$ ) in the water productivity components for ET<sub>100</sub> and ET<sub>75</sub> irrigation regimes. The best water productivity was observed for the ET<sub>75</sub> drip irrigation regime.

Therefore, the ET<sub>75</sub> regime was recommended for the two pepper varieties to ensure sustainable cultivation and production of the two varieties in the study area.

**Keywords:** Drip irrigation; *Capsicum chinense*; water productivity; water stress; *Capsicum frutescens*.

## 1. INTRODUCTION

Peppers (*Capsicum* spp.) belong to the family Solanaceae. It is a vital vegetable crop majorly consumed worldwide as a spice. It is a native of tropical South America specifically Brazil which is known to be the natural home of peppers [1]. It is extensively cultivated in every country of the world [2]. There are about 25-30 species of *Capsicum* with *Capsicum annuum* being the most extensively grown and cultivated species [3]. *Capsicum chinense* is produced in the derived Savanna and drier Savanna zone areas of the southwestern Nigeria [4]. The production of pepper has increased in recent years with Nigeria globally recognized as one of the highest producers [5]. Pepper as a fruit vegetable formed portion of the cropping system being a constituent of local foods across Nigeria [6]. The favourable climatic condition in Nigeria supports its growth and production. Peppers are tropical crops and grow best within temperatures range of 18 and 30°C. The crop can acclimatize to different soil types but grow better in a well-draining sandy soil with a pH between 6 and 7. Pepper is required to be planted in a raised bed and in areas that receive full sunlight for most hours of the day [1].

Water resources are now under increasing pressure due to the rapidly increasing population and competing demand from other water consuming sectors. As a result, water-saving agriculture is becoming the most effective way to solve the problem of water shortage and competition in agriculture. Drip irrigation is a well-known and established method for attaining high efficiencies in water use of crops by drenching only a restricted part of the root zone [7;8]. This system of irrigation contributes to the sustainable use of water resources for agriculture. With the drip irrigation systems, application of both water

and nutrients can be carried out directly to the crop at the root level, with observable effects on the yield and water savings consequently increasing the irrigation performance [9;10]. The efficient and cost-saving use of water for irrigation is becoming increasingly necessary. The aspect of agronomic management of water utilization by the crop is commonly referred to as water-use efficiency (WUE). This WUE can be achieved through application of deficit irrigation, irrigation scheduling, and other improved agricultural practices aimed at increasing crop yield [11;12]. Also, in terms of water and increased yield, drip irrigation has been verified to be a success [9].

Pepper can be cultivated as a rain-fed crop or raised fully under irrigation in areas with a very little or unsteady amount of rainfall [13]. The moisture content of the soil and the predominant temperature has significant influences on the growth and yield of pepper [13]. The amount of stored soil moisture for the cultivation of peppers may not be adequate for higher yield under varied soil and agroclimatic conditions. Availability of ecological resources and stress factors of the growing season affects the growth and yield response of crop species differently as there are disparities in prevailing soil and climatic atmospheres at diverse seasons of sowing [14].

Inadequate water results in water-stressed crop. Precise water use consumption of pepper must be known and sustained for its growth, development and yield. Many aspects of plant physiology are affected by water stress. Water stress reportedly affects photosynthetic rate, chlorophyll content, transpiration, stomatal conductance and crop growth [15;16]. It also has effects on yield because whenever actual evapotranspiration (ET<sub>a</sub>) is less than maximum evapotranspiration (ET<sub>max</sub>), evapotranspiration

deficit (ET<sub>d</sub>) occurs and yield is reduced below the maximum yield (Y<sub>max</sub>) [15]. Water deficit is an imperative factor in deciding the responses and adaptations of a species to water stress.

Attempts have been made to grow pepper under deficit irrigation in some parts of Nigeria but none of this attempt has been made in Ilaro, Ogun State, Nigeria [17;18;19;20]. The objective of this study was to determine water use efficiency and productivity of two species of peppers under different irrigation regimes of water application rates relative to actual crop evapotranspiration needs.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out during the dry seasons of 2017/2018 and 2018/2019 respectively, at the Training and Research Farm of the Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, Ilaro, Ogun State, Nigeria. Ilaro is located on latitude 6°53'11.5" N and longitude 3°1'13.8" E and at an altitude of 89 m above sea level. The location of the experiment is in the sub-humid area with two distinct seasons. The rainy season commences in April and ends in early November while dry time of the year commences from early November to March. The climate is favorable for pepper cultivation under supplementary or full irrigation regimes. In recent time, there is inconsistency in the monthly distribution of rainfall. This is making it difficult to predict the real amount of rainfall contributing to the crop water use during both wet and dry seasons of the year.

### 2.2 Pre-cropping Soil Sampling and Analysis

The core soil samples of the experimental site (0-15cm) were taken randomly by using soil auger in September 2017, a month before ploughing and other land preparations were carried out.

This was done in the month of August 2017. The core samples were bulked, mixed thoroughly and sieved through 2 mm sieve. The composite samples were subjected to routine laboratory analysis for the following: pH, soil organic matter, sodium, nitrogen, phosphorus, potassium, magnesium content and others. The textural classification was determined for both the

nursery and permanent site using sieve analysis and categorizes with USDA textural triangle. The result of the analysis is presented in Table 1.

The mean annual rainfall in Ilaro ranged from 1,200 to 1,350 mm, while the mean temperatures during wet and dry seasons are 23.6 and 36.2°C respectively. Table 1 show the physicochemical and granulometric compositions of the soil in the study area.

### 2.3 Description of the Experimental Procedures

Land preparation began with ploughing and harrowing of the experimental field in both seasons follow by field layout.

#### 2.3.1 Experimental design and layout

The experiment was a 2 x 4 factorial experiment arranged in a randomized complete block design (RCBD) with two varieties of pepper (*Capsicum chinense* and *Capsicum frutescens*), four drip irrigation regimes: 100% (ET<sub>100</sub>), 75% (ET<sub>75</sub>), 50% (ET<sub>50</sub>) and 25% of actual crop evapotranspiration (ET<sub>25</sub>). The experiment was carried out in 2017/2018 late season and repeated in the late season of 2018/2019. The experiment was replicated four times. The two pepper varieties selected were *Capsicum chinense* and *Capsicum frutescens* locally known as "Atarodo" and "Sombo" respectively.

Experimental field of 12 by 23 m was prepared and divided into two blocks. Each block was divided into four plots as shown in Plate 1 representing each treatment. The first block served as the control for the experiment. Each plot consists of three drip lines spaced 40 cm apart and the dimensions of the plot were 12 by 2 m. A buffer zone of 1 m was provided between plots in the block. Also, each plot was subdivided into four sub-plots of 3 m long. Two pepper varieties Atarodo (A) and Sombo (S) were planted in alternate order on each plot as S-A-S-A.

The irrigation system was a gravity-fed surface drip irrigation system that consisted of an electrically operated submersible pump to lift water from Borehole sited about 300 m away from the experimental plot to an overhead tank of 25 m<sup>3</sup> capacity. The yield of the well and its water quality were adequate for irrigation demand of the crop under investigation. The drips types were pressure compensatory with a diameter of 16 mm discharging at a rate of 5 l/hr.

**Table 1. Physico-chemical and granulometric compositions of the soil in the study area**

pH	Textural Class	Sand	Silt	Clay	Organic matter	P	N	Total porosity	Organic carbon	Bulk density	EC	Mg	Ca	Na	K
		.....(%).....							(g/kg)	(mg/m <sup>3</sup> )	d/S/m)	..... (mol/kg) .....			
6.2	Loam	76.68	9.84	13.48	2.28	10.36	0.43	48.24	1.32	1.43	8.10	1.89	7.91	0.69	0.76

*Note: pH (H<sub>2</sub>O); P, N, EC, Mg, Ca, Na, K = available phosphorus, available nitrogen, Electrical Conductivity, Magnesium, Calcium, Sodium and potassium, respectively*

The drip emitters spacing is 40 cm and the drip lines are spaced 50 cm apart to give plant population of 50,000 stands per hectare as recommended [17]. Water meters were installed to quantify the amount of water applied in every irrigation operation which usually lasts for sixty minutes. The quantity of water applied was selected based on the agronomical requirements of the capsicum annum at effective rooting zone depth of 0.31 m and wetting diameter of 41.67 m/km [18]. Pepper seeds used were obtained from the National Institute of Horticulture (NIHORT), Ibadan, Nigeria to ensure the seeds were of pure and good quality.

The seeds were nursed and transplanted at 6 weeks after planting (WAP). Poultry manures were applied and incorporated into all bed across the treatments before transplanting seedlings using standard practices. There was no fertilizer application throughout the crop growing seasons. Standard methods of pest management practices and manual methods of weed control were adopted in controlling the pests and weeds respectively, in the plot.

### 2.3.2 Application of Irrigation

Irrigation was applied uniformly to all plots for 3 weeks after transplanting (WAT) in order to ensure proper crop establishment. Irrigation regime treatments were imposed from 9 WAP (i.e 3WAT) in both cropping years. The irrigation interval was fixed. Irrigation was performed daily by varying the water depth applied as a function of the crop evapotranspiration, except periods that had rainfalls.

## 2.4 Data Collection

### 2.4.1 Irrigation related parameter

Amount of rainfalls were measured with the aid of rain-guage during the experiment. Soil moisture content was monitored on weekly basis from one week after transplanting (WAT) using a hand-held digital soil moisture meter-Lutron PMS – 714 developed in Australia. The moisture meter was calibrated against the gravimetric method. The mean absolute error (percent difference between the Lutron PMS - 714 and gravimetric) was 15%.

Actual evapotranspiration was used in obtaining the ETa used for the study based on submission of [17]. The equation was stated as:

$$ETa = I + P + D + R + \Delta S \quad (1)$$

Where: ETa = Actual evapotranspiration (mm)

I = Irrigation (mm), P = Precipitation (mm), D = Drainage (mm), R = Runoff (mm) and  $\Delta S$  = Change in soil water storage (mm).

### 2.4.2 Growth and yield measurements

The growth parameters such as plant height, stem diameter and number of leaves per plant were measured. Two plants were tagged per plot for weekly growth parameter data collection. Plant heights were measured with measuring tape and stem girth was measured with digital Vernier caliper. Growth parameters were obtained from 3 weeks after transplanting (3 WAT) when the irrigation regime was imposed. Harvestable yields of the two peppers varieties were determined on weekly interval starting from when harvesting began at 10WAT (16 WAP). Matured fresh peppers were hand-picked for 5 successive weeks and cumulative values for each treatment combinations were documented. The weight of harvested fruits obtained from each plot was recorded for every harvest and the total yield per treatment plot in kg was calculated as described by [20].

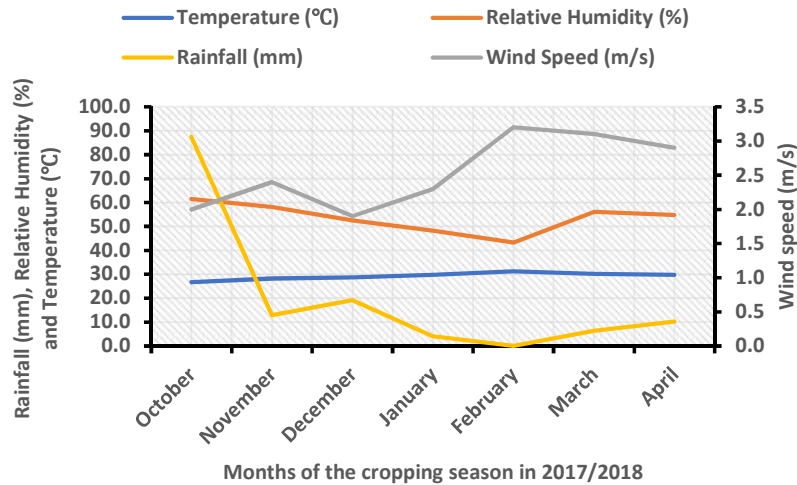
## 2.5 Statistical Analysis

Growth and yield parameters collected were subjected to Analysis of variance (ANOVA) and significant means separated using Duncan Multiple Range Test at 5% probability level.

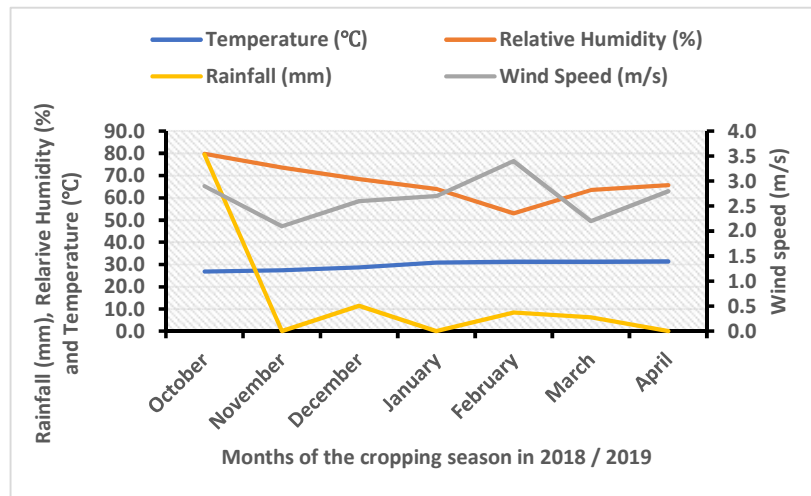
## 3. RESULTS AND DISCUSSION

### 3.1 Climatic Data

The study was conducted to evaluate response of two local varieties of pepper to water stress during the dry season under surface drip irrigation. During the cropping seasons, the average temperature, relative humidity and wind speed recorded during 2017/2018 and 2018/2019 cropping seasons were 29.2°C, 53.5% and 2.5 m/s and 29.7°C, 66.9% and 2.7 m/s while the total precipitation was 136.9 mm and 126.2 mm for 2017/2018 and 2018/2019 cropping seasons, respectively as shown below in Fig. 1a & 1b. This necessitated growing the crop under irrigation. The climatic data observed during the two cultivation periods (October to April) 2017/2018 and 2018/2019 are shown in Figs. 1a and 1b. The highest rainfall of 87.4 and 79.5 mm was observed in the month of October 2017 and 2018 respectively as revealed in the Figs. 1a and 1b.



**Fig. 1a. Monthly temperature (°C), relative humidity (%), rainfall (mm) and wind speed (m/s) during the 2017/2018 cropping period**



**Fig. 1b. Monthly temperature (°C), relative humidity (%), rainfall (mm) and wind speed (m/s) during the 2018/2019 cropping period**

These measured weather data fall within the acceptable values recommended for the cultivation of *Capsicum* spp in the tropics especially during the dry season. The plant has been reported to grow well in warm climate especially at temperature range of 18 to 27°C during the day and 15 to 18°C at night [21;20].

### 3.2 Soil Moisture Monitoring

The average moisture monitored for the soil depth of 0 - 15 cm commencing from 8 weeks after planting in the experimental plots for the two growing seasons were shown in Figs. 2a - 2d.

The soil moisture results indicated that the highest moistures were stored in plots with ET<sub>100</sub> irrigation regime. The least average moisture values were obtained in plots with ET<sub>25</sub> irrigation regime which has the least water application in both seasons.

### 3.3 Growth Parameters

#### 3.3.1 Plant height under variable water application/irrigation regime

The irrigation regime significantly affected the height of both pepper varieties (Figs. 3a and 3b).

There was a gradual and steady increase of plant heights in all the treatments during the cropping seasons. From 12 WAP, the plant heights were significantly impacted by the water application regime. Irrigation regime  $ET_{100}$  differ significantly from  $ET_{25}$  regime, there were no significant differences ( $p>0.05$ ) in plant height among other treatments. At 18 WAP, Irrigation regime  $ET_{100}$  resulted in the highest average plant height of 192.5 and 158.3 cm with the least

value of 132.1 and 115 cm were obtained under  $ET_{25}$  regime in Atarodo (*Capsicum chinense*) and Sombo (*Capsicum frutescens*), respectively. Growth of plant was influenced by the irrigation regime and level of available soil moisture. Plant height was better with higher level of irrigation water applied. This agrees with the finding of [22] in which a decrease in irrigation water applied resulted in a significant decrease in plant height.

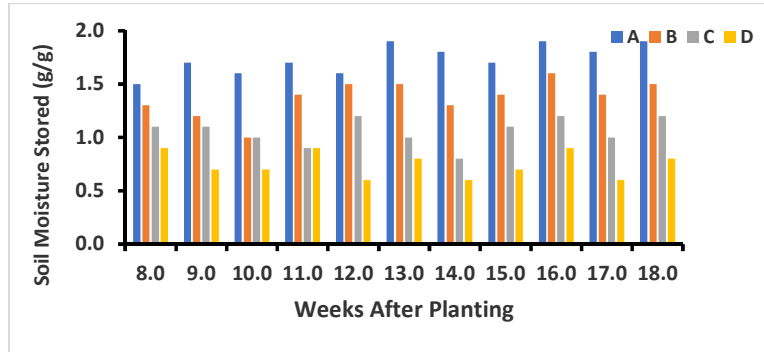


Fig. 2a. Soil moisture stored under Atarodo pepper variety at various WAP for the different irrigation regime (A=  $ET_{100}$ , B=  $ET_{75}$ , C=  $ET_{50}$ , D=  $ET_{25}$ ) in 2017/2018

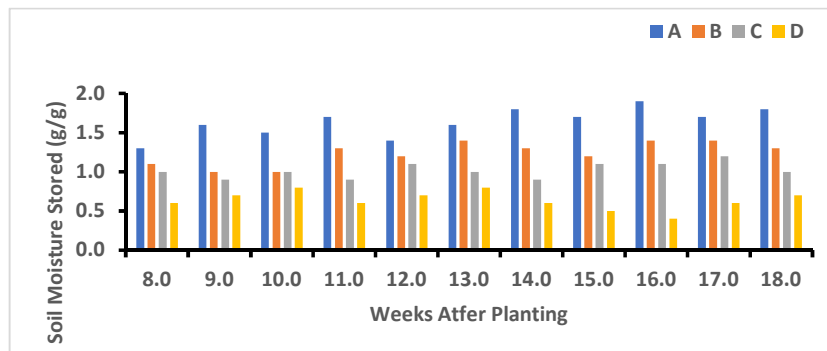


Fig. 2b. Soil moisture stored under Sombo pepper variety at various WAP for the different irrigation regime (A=  $ET_{100}$ , B=  $ET_{75}$ , C=  $ET_{50}$ , D=  $ET_{25}$ ) in 2017/2018

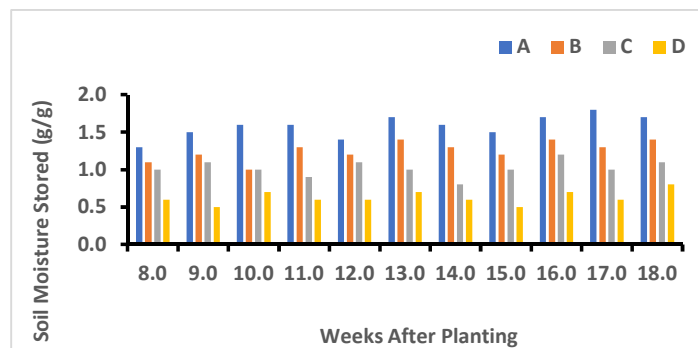
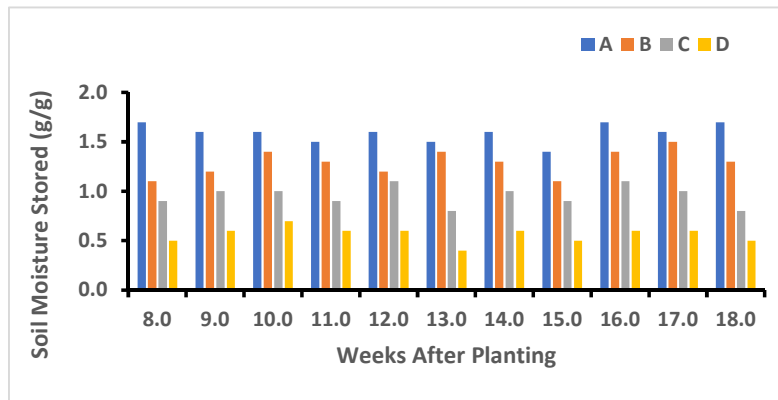
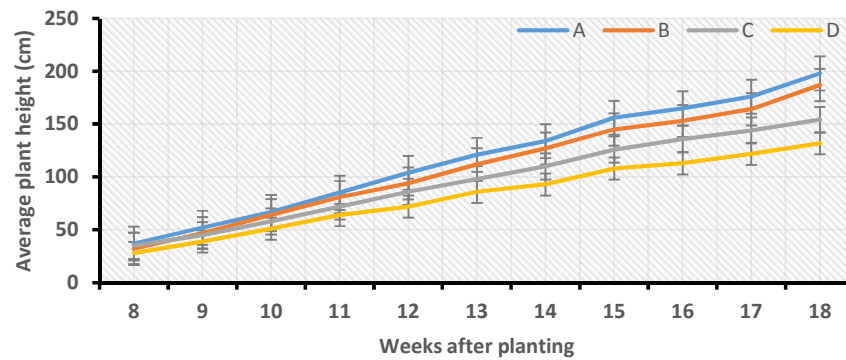


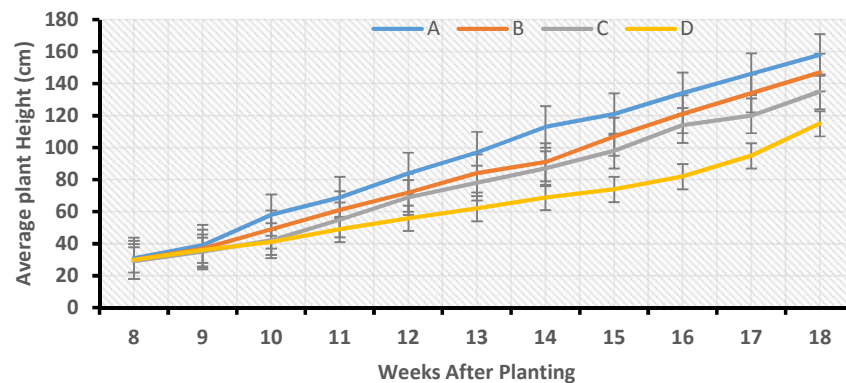
Fig. 2c. Soil moisture stored under Atarodo pepper variety at various WAP for the different irrigation regime (A=  $ET_{100}$ , B=  $ET_{75}$ , C=  $ET_{50}$ , D=  $ET_{25}$ ) in 2018/2019



**Fig. 2d.** Soil moisture stored under Sombo pepper variety at various WAP for the different irrigation regime (A=  $ET_{100}$ , B=  $ET_{75}$ , C=  $ET_{50}$ , D=  $ET_{25}$ ) in 2018/2019



**Fig. 3a.** Weekly average plant height of Sombo pepper variety as influenced by irrigation regime



**Fig. 3b.** Weekly average plant height of Atarodo pepper variety as influenced by irrigation regime



### 3.3.2 Stem diameter

The results of the average stem diameter for all the treatments in the two pepper varieties are shown in Table 2. Increase in the stem diameters was recorded with an increase in water applied in Atarodo (*Capsicum chinense*) variety during cropping seasons. However, in Sombo (*Capsicum frutescens*), increased water application regime did not translate to significant increase in stem diameter. Irrigation regime ET<sub>100</sub> has the highest value of stem diameter while the least was recorded for ET<sub>25</sub> regime in Atarodo (*Capsicum chinense*) variety whereas in Sombo (*Capsicum frutescens*) variety, irrigation regime ET<sub>75</sub> resulted in the highest stem diameter with the least value recorded under ET<sub>25</sub> regime.

The highest stem diameter of 2.1 and 2.4 cm and minimum values of 1.9 and 1.7 cm were obtained in Sombo (*Capsicum frutescens*) and Atarodo (*Capsicum chinense*), respectively during the cropping seasons. The results

obtained were comparable to the findings of [23;17] that soil nutrients and quantity of applied water could influence growth and development of the crop.

### 3.3.3 Number of leaves per plant

The average number of leaves per plant is as shown in Table 3. Average number of leaves in Sombo (*Capsicum frutescens*) variety ranged from 38 to 54 at maturity stage with highest numbers of leaves recorded with irrigation regime ET<sub>100</sub> and least average values obtained in treatment irrigation regime ET<sub>25</sub>. Similarly, in Atarodo (*Capsicum chinense*) variety, irrigation regime ET<sub>100</sub> resulted in the highest number of leaves (47) and minimum leaves number of 32 was obtained with irrigation regime ET<sub>25</sub>. According to [17], water and nutrient application influence the growth parameters especially the number of leaves. This result also corroborates the assertion made by [24], that soil moisture variability strongly influenced post-germination growth.

**Table 2. Average weekly values of stem diameters (cm) as influenced by irrigation regime**

Irrigation regime	Weeks After planting										
	8	9	10	11	12	13	14	15	16	17	18
<b>Sombo (<i>Capsicum frutescens</i>)</b>											
A	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.9	2.0
B	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1.7	1.9	2.0	2.1
C	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	1.9
D	0.7	0.8	0.9	1.0	1.1	1.1	1.2	1.5	1.6	1.7	1.8
<b>Atarodo (<i>Capsicum chinense</i>)</b>											
A	0.9	1.1	1.2	1.3	1.4	1.6	1.8	1.9	2.1	2.2	2.4
B	0.8	1.0	1.1	1.2	1.3	1.5	1.6	1.7	1.8	2.0	2.1
C	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.7	1.9	2.0
D	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7

**Table 3. Average number of leaves in all the treatments against week after planting**

Irrigation regime	Weeks After planting										
	8	9	10	11	12	13	14	15	16	17	18
<b>Sombo (<i>Capsicum frutescens</i>)</b>											
A	15	18	22	27	31	34	37	40	44	49	54
B	13	15	20	24	28	32	35	39	42	46	51
C	12	14	16	19	21	24	29	33	38	41	44
D	10	13	14	18	21	25	27	30	32	35	38
<b>Atarodo (<i>Capsicum chinense</i>)</b>											
A	14	17	21	23	25	27	30	34	37	41	47
B	13	15	18	21	23	25	27	29	32	37	41
C	10	12	15	18	10	22	24	26	30	34	37
D	8	11	13	16	18	20	22	25	27	30	32

### 3.3.4 Number of fruits per plant

The number of fruits harvested per plant was higher with increase in water application for both varieties during the cropping seasons (Fig. 4a and b). However, there was no significant difference in the number of fruit per plant at 5% probability level in both seasons. An upsurge in fruit number is one of the greatest significant factors influencing yield. According to [22], to avoid deprived fruit size and shape with increase yield, an even supply of soil water all through the growing season is required [25].

During the cropping season, irrigation regime ET<sub>100</sub> with high water depth application produced

the highest average fruit number of 32.2 and 37.1 in Sombo (*Capsicum frutescens*) and Atarodo (*Capsicum chinense*), respectively. The lowest average fruits numbers of 13.6 and 12.1 were recorded with irrigation regime ET<sub>25</sub> in both varieties during the cropping season. There is a positive response in number of fruits per plant to quantity of applied water. [26], observed that soil moisture lower than 65% of field capacity decreased the number of fruit and increased the percentage of malformed fruit in tomatoes under drip irrigation in the greenhouse. Limiting the supply of irrigation water to crops is known to have immediate consequence on carbohydrate concentrations in the leaves and fruit [27].

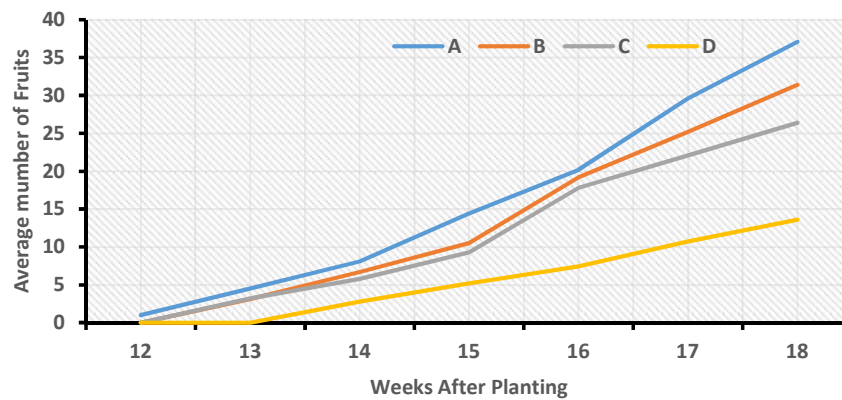


Fig. 4a. Average fruit number for Sombo pepper variety as influenced by different irrigation regimes

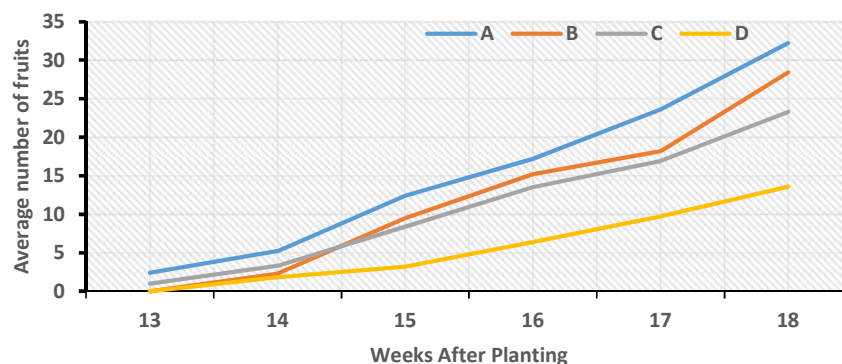


Fig. 4b. Average fruit number for Atarodo pepper variety as influenced by different irrigation regimes

**Table 4. The response of fruit parameters to variable water application**

Irrigation regime	<i>Sombo (Capsicum frutescens)</i>					<i>Atarodo (Capsicum chinense)</i>				
	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit Yield (t/ha)	WUE (kg/ha/mm)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit Yield (t/ha)	WUE (kg/ha/mm)
A	9.60	1.80	12.04	19.75	31.85	3.20	2.10	9.58	21.20	34.19
B	10.10	2.20	14.89	14.35	30.86	3.60	2.20	11.75	15.15	32.58
C	8.60	1.70	9.26	8.35	26.94	2.90	1.80	8.01	9.90	31.94
D	7.70	1.00	6.06	3.10	20.00	2.70	1.70	7.12	4.85	31.29

### 3.3.5 Fruit characters

The response of fruit length and other fruit characters to variable water application is shown in Table 4. There was progressive increase in fruit length, fruit width, fruit weight and fruit yield when the amount of water applied increased. In *Sombo (Capsicum frutescens)*, the fruit length varied from 7.7 to 9.6, fruit width varied from 1.8 to 1.0, fruit weight varied from 6.06 to 12.04 and fruit yield varied from 3.10 to 19.75. Highest average values were obtained with irrigation regime ET<sub>100</sub> and least with irrigation regime ET<sub>25</sub>. In the case of *Atarodo (Capsicum chinense)* variety, the fruit length ranged from 2.7 to 3.2, fruit width ranged from 1.7 to 2.1, fruit weight ranged from 7.12 to 9.58 and fruit yield varied from 4.85 to 21.20. Highest average values were obtained irrigation regime ET<sub>100</sub> and least with irrigation regime ET<sub>25</sub>.

There was no significant difference in fruit length under the various irrigation regimes at a 5% level. Similar results were reported by [28], who observed that there was no significant difference in fruit length and other fruit parameters observed during cropping season with various treatments carried out on pepper. Insufficient water supply lessens the length and weight of pepper fruits. This is in line with the findings of [29], that irrigation treatments influenced pepper fruit number, yield, and fruit size.

### 3.2.6 Water supply and productivity

In the *Atarodo (Capsicum chinense)* variety, the water application that provided the highest yield value (0.424 kg plant<sup>-1</sup>; 19.75 t ha<sup>-1</sup>) was 105.76 mm (ET<sub>100</sub>) and the least (0.097 kg plant<sup>-1</sup>; 4.85 t ha<sup>-1</sup>) was 26.4 mm equivalent to ET<sub>25</sub>. Likewise, *Sombo (Capsicum frutescens)* variety, the water application that provided the highest yield value (0.395 kg plant<sup>-1</sup>; 19.75 t ha<sup>-1</sup>) was 105.76 mm (ET<sub>100</sub>) and the least (0.062 kg plant<sup>-1</sup>; 3.10 t ha<sup>-1</sup>) was 26.4 mm equivalent to ET<sub>25</sub> as shown in Table 4.

## 4. CONCLUSION

The results indicated that Water use efficiency (WUE) and fruit yield of pepper were influenced by the different irrigation applications. The optimum yield of the two studied peppers can be obtained under ET<sub>100</sub> irrigation regime. Also, the yield parameters of the pepper reacted positively to variable depth of water applied. However, there was no significant difference in WUE of irrigation regime ET<sub>100</sub> and ET<sub>75</sub>). It is inferred that irrigating at 75% ET (ET<sub>75</sub>) in the study area will result in water-saving and maximum sustainable production of these pepper varieties.

## ACKNOWLEDGEMENT

The authors hereby express their gratitude and appreciation to the entire board of tertiary education trust fund (TETFUND) of Nigeria for the full sponsorship of this research project.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

- Raphael OD, Ogedengbe K, Fasinmirin JT, Okunade D, Akande I, Gbadamosi A. Growth-stage-specific crop coefficient and consumptive use of *Capsicum chinense* using hydraulic weighing lysimeter. *Agricultural Water Management*. 2018; 203:179-185. DOI: 10.1016/j.agwat.2018.03.011
- Adewoyin OB, Fagbayide SD, Oluwafemi MO. Effects of soil amendments on growth and yield of Pepper (*Capsicum frutescens* L.) fruits. *Environ-tropica. International Journal of the Tropical Environment*. 2012;9&10:130–135. Available: <http://repository.fuoye.edu.ng/bits/tream/123456789/1079/1>

3. Aliyu TH. The incidence, severity, and occurrence of four viruses infecting pepper (*Capsicum* spp.) in the Southern Guinea Savannah Agro-ecological Zone of Nigeria. *Agriculturae Conspectus Scientificus*. 2014;79(4):233-237.  
Available: [http://www.agr.unizg.hr/smotra/pdf\\_79/acs79\\_35.pdf](http://www.agr.unizg.hr/smotra/pdf_79/acs79_35.pdf)  
Accessed date: 16/07/2020.
4. Dada OA, Ogunsesu YO. Growth analysis and fruit yield of *Capsicum chinense*, Jackquin as Influenced by compost applied as foliar spray and soil augmentation in Ibadan, Southwestern Nigeria. *Journal of Agriculture and Sustainability*. 2016;9(1): 87 – 94.  
Available: <https://infinitypress.info/index.php/jas/article/view/1274>  
Accessed date: 13/06/2020
5. Erinle ID. Present status and prospects for increased production of tomato and pepper in Northern Nigeria. *Tomato and pepper in the tropics AVRDC Shauhua Taiwan*. 1989;545.
6. Ajayi AJ, Agele SO, Aiyelari OP. Influence of time of cowpea introduction at the establishment phase of pineapple on performance of pepper in a pineapple-pepper-cowpea intercropping system. *Journal of Experimental Agriculture International*. 2020;42(4):88-98.  
DOI: 10.9734/JEAI/2020/v42i430503
7. Assouline S, Cohen S, Mecbach D, Harodi T, Rosner M. Effects of Micro-drip irrigation on yield, water uptake and drainage in sweet corn. *Soil Science of American Journal*. 2002;66:228-235.  
Available: <https://access.onlinelibrary.wiley.com/doi/full/10.2136/sssaj2002.2280>  
Accessed date: 21/07.2020
8. Awe GO, Ogedengbe K. Performance evaluation of bamboo-pipe (*Bambusa vulgaris*, Schrad) and medi-emitter in a gravity-flow drip irrigation system. *Journal of Environmental Issues and Agriculture in Developing Countries*. 2010; 2(1).  
Available: [https://www.icidr.org/jeiad\\_291](https://www.icidr.org/jeiad_291)  
Accessed date: 12/08/2020
9. Nagaz K, Masmoudi MM, Mechlia NB. Effects of deficit drip-irrigation scheduling regimes with saline water on pepper yield, water productivity, and soil salinity under arid conditions of Tunisia. *Journal of Agriculture and Environment for International Development (JAEID)*. 2012; 106(2):85-103.  
DOI: <https://doi.org/10.12895/jaeid.2012-2.60>
10. Ankush A, Singh V, Sharma SK. Response of tomato (*Solanum lycopersicum* L.) to fertigation by irrigation scheduling in drip irrigation system. *Journal of Applied and Natural Science*. 2017;9(2).  
DOI: <https://doi.org/10.31018/jans.v9i2.13-42>
11. Quezada C, Fischer S, Campos J, Ardiles D. Water requirements and water use efficiency of carrot under drip irrigation in a Haploxerand soil. *Journal of Soil Science and Plant Nutrition*. 2010;11(1): 16-28.  
DOI: 10.4067/S0718-95162011000100002
12. Fagbayide SD, Ewemoje T, Oluwasemire K. Yield, growth, and water use efficiency of drip irrigated *Jatropha curcas* L. in South-Western Nigeria. *Journal of Sustainable Technology*. 2018;9(1):98–109.  
Avaialble: [www.futa.edu.ng/journal/home/paper](http://www.futa.edu.ng/journal/home/paper).  
Accessed date: 15/02/2020
13. Idowu-Agida OO, Nwaguma EI, Adeoye IB. Cost implication of wet and dry season pepper production in Ibadan, Southwestern. *Agriculture and Biology Journal of North America*. 2010;1(4):495-500.  
Avaialble: <http://www.scihub.org/ABJNA>  
Accessed date: 12/12/2019
14. Agele SO, Olabomi A. Growth, fruit set efficiency and blossom end rot in *Capsicum* spp in humid Southwest Nigeria. *Applied Tropical Agriculture*. 2010;15:112-124.  
DOI: 10.5376/ijh.2016.06.0022
15. Alatise MO. Growth, yield and water use pattern of maize under limited water supply". PhD Dissertation. Federal University of Technology, Akure Nigeria. 2002;183.
16. Anjum SA, Xie X, Wang L, Saleem MF, Man C, Lei W. Morphological, physiological and biochemical responses of plants to drought stress. *African Journal of Agricultural Research*. 2011;6(9):2026-2032.  
DOI: 10.5897/AJAR10.027
17. Akinbile CO, Yusoff MS. Growth, yield, and water use pattern of chilli pepper under different irrigation scheduling and management. *Asian Journal of Agricultural Research*. 2011;5(2):154-163.  
DOI: 10.3923/ajar.2011.154.163

18. Adeoye PA, Adesiji RA, Oloruntade AJ, Njemanze CF. Effect of irrigation intervals on growth and yield of bell pepper (*Capsicum annuum*) in a tropical semi-arid region. *Journal of Experimental Agriculture International*. 2014;23(1):515-524. Available: <https://staff.futminna.edu.ng/ABE/content/journal/PF0939/3.pdf> Accessed date: 16/07/2020
19. Agele SO, Agbona IA, Ewulo BS, Anifowose AY. Drip irrigation scheduling for optimizing productivity of water use and yield of dry season pepper (*Capsicum annuum* L) in an inland valley swamp in a humid zone of Nigeria. *International Journal of Horticulture*. 2014;4(14). DOI: 10.5376/ijh.2014.04.0014
20. Yusuf KO, Ogunlela AO. Effect of magnetic treatment of water on evapotranspiration of tomato. *Arid Zone Journal of Engineering, Technology, and Environment*. 2017; 13(1):86-96. Available: <http://oaji.net/articles/2017/4371-1496974873.pdf>
21. Raphael OD, Ogedengbe K, Amodu MF. Effects of treated greywater irrigation regimes and mulches on yield of *Capsicum chinense* under surface drip irrigation system. *IOP Conference Series: Earth and Environmental Science*. 2020; 44(5). DOI: 10.1088/1755-1315/445/1/012017
22. Ayodele OJ, Alabi EO, Aluko M. Nitrogen fertilizer effects on growth, yield and chemical composition of hot pepper (Rodo). *International Journal of Agriculture and Crop Sciences*. 2015;8(5): 666.
23. Sezen SM, Yazar A, Eker S. Yield and quality response of drip-irrigated pepper under Mediterranean climatic conditions to various water regimes. *African Journal of Biotechnology*. 2011;10(8):1329-1339. DOI: 10.5897/AJB10.1689
24. Campiglia E, Mancinelli R, Radicetti E, Marinari S. Legume cover crops and mulches: effects on nitrate leaching and nitrogen input in a pepper crop (*Capsicum annuum* L.). *Nutrient Cycling in Agroecosystems*. 2011;89(3):399-412. DOI:10.1007/s10705-010-9404-2
25. Fay PA, Schultz MJ. Germination, survival, and growth of grass and forb seedlings: Effects of soil moisture variability. *Acta Oecologica*. 2009;35(5):679-684.
26. Alao F, Alatise MO, Olanrewaju OO. Pepper's yield response to variable water application using micro-sprinkler system. *Proceedings of the 2017 Annual Conference of the School of Engineering & Engineering Technology (SEET), The Federal University of Technology, Akure, Nigeria*. 2017;458-467.
27. Liu H, Duan AW, Sun JS, Liang YY. Effects of soil moisture regime on greenhouse tomato yield and its formation under drip irrigation. *Ying yong sheng tai xue bao. The Journal of Applied Ecology*. 2009;20(11):2699-2704.
28. Miller SA, Smith GS, Boldingh HL, Johansson A. Effects of water stress on fruit quality attributes of kiwifruit. *Annals of Botany*. 1998;81(1):73-81. Available: <https://doi.org/10.1006/anbo.1997.0537>
29. Dagdelen N, Yilmaz E, Sezgin F, Gurbuz T. Effects of water stress at different growth stages on processing pepper (*Capsicum annum* Cv. Kapija), Yield Water use and Quality Characteristics. *Pakistan Journal of Biological Sciences*. 2004; 7(12):2167-2172.

© 2020 Oluwagbayide et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:  
The peer review history for this paper can be accessed here:  
<http://www.sdiarticle4.com/review-history/61423>