

# COMPARATIVE ASSESSMENT OF CROP WATER PRODUCTIVITY OF DRIP IRRIGATED GREEN PEPPER UNDER POLY-HOUSE AND OPEN-FIELD CONDITIONS

## ABSTRACT

Crop water productivity (CWP) is a crucial factor in determining the sustainability of agricultural practices. Drip irrigation is a method that has shown potential in improving CWP in crop production. The study aimed to compare the crop water productivity of green pepper production in the two different environments. The experiment was conducted during the dry seasons of 2020/2021 and 2021/2022 at the Teaching and Research Field of Federal Polytechnic, Ado-Ekiti, Nigeria. The beds were prepared, nursery was established, drip irrigation system was installed and fumigation was carried out before transplanting. The experimental design was a randomized complete block (RCBD) with nine replications in each environment. The same design was applied to both poly-house and open-field conditions. The factors are environment (poly-house and open-field) and irrigation intervals of 5, 6 and 7 days ( $I_5$ ,  $I_6$  and  $I_7$ ). Data obtained were subjected to analysis of variance and Tukey's Honestly Significant Difference (HSD) was used for multiple comparison. Drip irrigation was applied to all plots at different irrigation intervals. The results showed that the crop water productivity under poly-house and open-field environments in 2020/2021 growing season were:  $I_5$ : 29.67,  $I_6$ : 36.97,  $I_7$ : 20.92 and  $I_5$ : 17.06,  $I_6$ : 21.45,  $I_7$ : 12.21 kg/m<sup>3</sup> in 2020/2021 growing seasons. Similarly, in the 2021/2022 cropping season, the CWP values were  $I_5$ : 16.90,  $I_6$ : 23.27,  $I_7$ : 12.95 and  $I_5$ : 9.60,  $I_6$ : 14.01,  $I_7$ : 6.81 kg/m<sup>3</sup>. The results revealed that water productivity was more efficient at low levels of water supply in the poly-house during the two growing seasons. The production of green pepper under poly-house increased water conservation, reduced nutrient leaching, enhanced crop productivity for sustainable agricultural practices and water management.

Keyword: Comparative, assessment, crop water, productivity, poly-house and open-field

## INTRODUCTION

The use of poly-house in arid regions decreases crop water requirements by reducing evapotranspiration. The plastic cover utilized on these structures changes locally the radiation balance by entrapping long-wave radiation and creates a barrier to moisture losses (Singh et al., 2005). As a result ETo is reduced by 60 to 85% compared to outside the poly-house (Fernandes *et al.*, 2003). This leads to clear reduction in water demand when compared to field agriculture. Thus, poly-house agriculture provides a way of increasing crop water use efficiency. This has been highlighted by Mears, (1990) who stated that: "While a poly-house is generally regarded as necessary to provide a warm environment in cold climates, it has also been shown that with

properly designed cooling system. It is possible to improve plant growing conditions under extensively hot conditions (Dalai et al., 2018). Adaptation of modern technologies to arid conditions will undoubtedly lead to increased opportunities for production of high value plants and materials in areas where the environment is extremely harsh (Seem et al., 2019). Protected cultivation also has the potential benefit of substantially increasing plant productivity per unit water consumption which is important in many areas where water sources are severely limited” Poly-house cultivation reduces evapotranspiration (ET) to about 70% of open field, therefore improving the water use, relative to unprotected cropping (Stanghellini, 1993). It obviously does not rain in the greenhouse, and water has to be provided by an irrigation system. In general, irrigation system is controlled to provide enough easily available water to plants, and thus transpiration is close to its potential value (Jolliet, 1999).

## **MATERIALS AND METHODS**

### **Description of the Experimental Site**

The study was carried out at the Teaching and Research Farm of the Federal Polytechnic, Ado-Ekiti, Nigeria. The site is located on Longitude  $4^{\circ} 45^1$  to  $5^{\circ} 45^1$  E and Latitude  $7^{\circ} 15^1$  to  $8^{\circ} 5^1$  N. The mean minimum and the maximum temperatures of the study area are 27 and 30°C, respectively. The study area is characterized with highly seasonal rainfall with distinct wet (April – October) and dry (November – March) seasons.

### **Experimental Design and Bed Preparation**

The experiment was conducted during the dry seasons of 2020/2021 and 2021/2022. The green pepper crop was planted in the experimental field. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and nine (9) treatment combinations consisting of three irrigation intervals of 5, 6, and 7 ( $I_5$ ,  $I_6$  and  $I_7$ ) days under poly-house and open-field conditions.

Land preparation was done manually inside the poly-house and in the open-field using cutlasses, diggers, hoes and unburied grasses was properly removed to ensure a clean field. Six (6) raised beds of 24 m length, 1 m width and 0.40 m height were made both in the poly-house and open-field, respectively for cultivation of green pepper crop. Three lysimeters were installed on each bed both in the poly-house and open-field conditions. Manure was incorporated into the soil

during bed preparation. The size of each block both in the poly-house and open-field was 1 m by 24 m.

### **Experimental Field Layout and Installation of Drip Irrigation**

The irrigation was layout with two rows in a block. There was six (6) blocks and each block contained three (3) experimental units. The installation of flow meter was carried out on the delivery pipe to accurately measure the volume of water supplied to the field. The flow meter was validated for confirmation of its accuracy. The laterals was spaced at 40 cm with an emitter spacing of 30 cm shown in Plates 1 and 2. The spacing of the pepper therefore was 40 cm x 30 cm. Drip irrigation system was used in irrigating as well as fertigating the green pepper in poly-house and open-field. Same lateral line which was used in the poly-house was used in the open-field and control valve was provided for each drip line to regulate the flow of required quantity of water to each plot.

### **Planting and Field Management**

The seedlings were ready for transplanting between 28 and 30 days. The plots (poly-house and open-field) was fumigated and irrigated to its field capacity before transplanting so as to provide favourable moisture condition for settlement of seedlings. The field was marked with a spacing of 40 cm × 30 cm in both the directions. Seedlings was dipped into starter solution to facilitate root formation and early establishment. Seedlings were transplanted out simultaneously on the open-field and the poly-house at planting distance of 30 cm within rows and 40 cm between rows per bed.

### **Measurement of Total Weight of Fresh Fruit and Crop Water Productivity**

Fresh weight of ten randomly selected mature fruits at marketable stage was weighed and recorded in kilograms using electronic balance and the average was computed while the crop water productivity (CWP) is the ratio of crop yield and the amount of water consumed by the plants. This was estimated as:

$$CWP = \frac{\text{Crop yield kg}}{\text{Consumptive use m}^3}$$

### **Statistical Analysis**

Statistical analysis was performed using Microsoft Excel, and Statistical Packages. All the irrigation patterns were subjected to statistical analysis to determine the mean, standard deviation and coefficient of variation. Statistical significant differences in consumptive use and yields across irrigation intervals systems were tested by one-way Analysis of Variance (ANOVA) within the General Linear Model (GLM) procedure. Multiple comparisons were performed using Tukey's Honestly Significant Difference (HSD) post hoc test at 5% levels of significance.

## RESULTS AND DISCUSSION

The crop water productivity of drip irrigated green pepper was estimated at different irrigation frequencies under poly-house and open-field conditions during 2020/2021 and 2021/2022 growing seasons. The results are presented and discussed as follows.

The effect of cropping environment and irrigation intervals on crop water productivity (CWP) ( $\text{kg}/\text{m}^3$ ) of green pepper in 2020/2021 and 2021/2022 cropping seasons is presented in Table 1. During 2020/2021 growing season, there was no significant difference ( $p < 0.05$ ) in crop water productivity (CWP) of green pepper in both poly-house and open-field under  $I_5$ . Similar results are observed under  $I_6$  and  $I_7$ . However, the CWP is significantly varied under their irrigation intervals in the order  $I_6 > I_5 > I_7$ . Similar trends were observed for 2021/2022 growing season under poly-house and open-field cropping environment. Numerically, the CWP in open-field during the two growing seasons were lower than under poly-house environment. The highest CWP was recorded at  $I_6$  under poly-house in 2020/2021 while lowest CWP was obtained at  $I_7$  under and open-field in 2021/2022 growing seasons, respectively.

Table 1: Effect of cropping environment and irrigation intervals on crop water productivity (CWP) ( $\text{kg}/\text{m}^3$ ) of green pepper in 2020/2021 and 2021/2022 cropping seasons

Year (Y)	Cropping Environments (CE)	Significance of the difference between irrigation intervals (II) and cropping environments (CE)			
		I <sub>5</sub>	I <sub>6</sub>	I <sub>7</sub>	Average
2020/2021	Poly-House	29.67b	36.97a	20.92c	29.91A
	Open-Field	17.06b	21.45a	12.21c	16.91B
	Average	23.36b	29.21a	16.57c	
2021/2022	Poly-House	16.90b	23.27a	12.95c	17.71A
	Open-Field	9.60b	14.01a	6.81c	10.14B
	Average	13.25b	18.64a	9.88c	

The results of the effect of drip irrigation frequency and cropping environment on crop water productivity (CWP) of the green pepper crop during the 2020/2021 and 2021/2022 growing seasons is presented in Figure 1. The significantly ( $p < 0.05$ ) highest CWP was obtained from treatment I<sub>6</sub> while treatment I<sub>7</sub> gave the lowest CWP in both cropping environments and growing seasons. Regardless of cropping environment, I<sub>6</sub> had the highest (36.97 kg/m<sup>3</sup>) CWP compared to I<sub>5</sub> (29.67 kg/m<sup>3</sup>) and I<sub>7</sub> (20.97 kg/m<sup>3</sup>) in the 2020/2021 growing season while same trend I<sub>6</sub> > I<sub>5</sub> > I<sub>7</sub> was observed in the 2021/2022 growing season.

A comparison of the two cropping environments showed that higher ( $p < 0.05$ ) CWP was observed in the poly-house compared to the open-field in both growing seasons (Figure 2). The 2020/2021 growing season had higher CWP than that of 2021/2022 growing season.

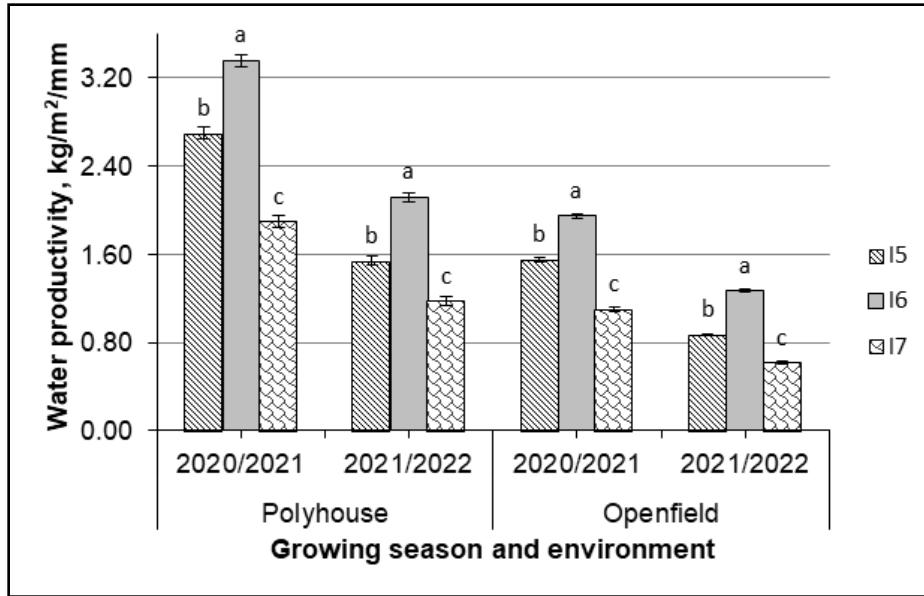


Figure 1: Crop water productivity at different intervals under growing environment

I<sub>5</sub>: five irrigations per week; I<sub>6</sub>: six irrigations per week; I<sub>7</sub>: seven irrigations per week

Bars with different letters differed significantly at 5% level of probability by Tukey test

Capped vertical lines are the standard error of mean.

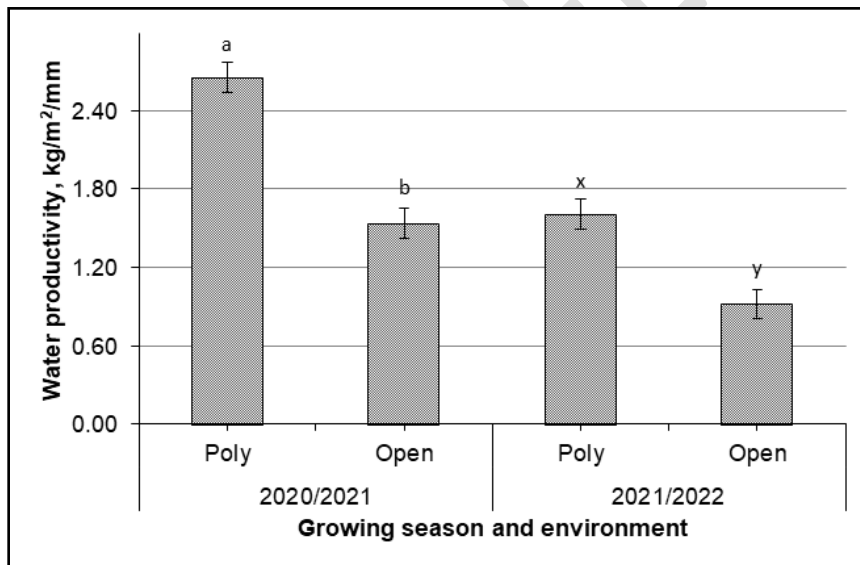


Figure 2: Crop water productivity during growing season and environment.

Bars with different letters differed significantly for each growing season at 5% level of probability by T-test

Capped vertical lines are the standard error of mean.

Poly-house cultivation consistently yielded the maximum crop water productivity (CWP) throughout both seasons. Furthermore, the highest CWP values were obtained at an irrigation interval of 6 days per week, while the lowest values were observed at an interval of 7 days per week for both cropping environments and across both seasons. Statistical analysis indicated that both the cropping environment and irrigation interval significantly influenced the CWP of green pepper in both growing seasons. The use of different cropping environments and irrigation intervals resulted in slight variations in the CWP of green pepper.

The probable reasons for the obtained results on CWP of green pepper under poly-house could be attributed to several factors. Poly-house cultivation provides a controlled environment, allowing for better regulation of temperature, humidity, and light, which can enhance crop productivity. The protective structure of the poly-house may also shield the plants from adverse weather conditions, pests, and diseases. Additionally, the irrigation interval of 6 days per week may have facilitated optimal water availability for the plants, promoting higher CWP. Conversely, an interval of 7 days per week may have resulted to over-irrigation while an irrigation of 5 days per week may have led to under-irrigation and reduced productivity. The differences observed between the two growing seasons could be attributed to variations in climatic conditions, management practices, or other factors not explicitly mentioned in the provided information. The results are in conformity with findings of Zhang *et al.* (2022); Huang *et al.* (2022); Wang *et al.* (2021); Li *et al.* (2020) and Wu *et al.* (2020) who reported that the crop water productivity of tomato, maize, vegetable production, cabbage and lettuce, respectively are higher under poly-house conditions than in the open-field environments.

## **CONCLUSION AND RECOMMENDATIONS**

The maximum and minimum crop water productivity of 39.97 and 12.21 kg/m<sup>3</sup> was obtained under poly-house and open-field condition in 2020/2021 growing season, while the greatest and lowest crop water productivity of 23.27 and 6.81 kg/m<sup>3</sup> was recorded under poly-house and open-field conditions in 2021/2022 growing seasons, respectively. The crop water productivity of green pepper is significantly higher under poly-house environment compared to crop water productivity under open-field in both cropping seasons. The confined environment created by the poly house may have contributed to better water management and reduced water losses compared to the open field. The crop water productivity contributed to optimization of water management strategies for green pepper cultivation which potentially minimizes water

consumption in the production of green pepper. Achieving higher crop water productivity in pepper production is essential for sustainable water management practices. The cultivation of green pepper under poly-house environment is recommended for the development of effective and efficient crop management strategies for sustainability of green pepper production in the current and future.

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