An analysis of rain-fed and irrigation in the growth and yield of cucumber (*cucumis sativus l.*)

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Cucumber (Cucumis sativus L.) requires relatively more water for growth and yield than other crops, yet its cultivation in most of the tropical region including Nigeria is characterised by threat to optimum water availability (rainfall). Thus, artificial water supply is accepted as an alternative water source to make cucumber available during the dry season farming. With the changing climate and its' impact on water supply, there is need for more information and data to understand the synergy between cucumber production and water for proper planning. This paper therefore aimed at determining the response of cucumber production to rain-fed and irrigation focusing on the growth and yield parameters. Two experiments were carried out one on irrigated control cucumber cultivation and the second on open cultivation of cucumber which depended on rainfall for seven weeks. The same treatments were given to both experiments except their water need. Data on plant height (cm), weight of harvested cucumber were collected and determined. Rainfall data(mm) between July and September was sourced from the University of Lagos Meteorological Station for a comparative analysis. The result depicted rainfed cucumber plants recorded a higher mean value of the number of harvested fruits (3.33) and weight of harvested fruits (1.33kg) than irrigation cucumber plants 1.33 and 0.5 kg respectively. Thus, the rainfed technique is better for high cucumber yield. The study suggested that cucumber cultivated with rain water perform better with significant differences in the height, growth and yield performances that with borehole irrigated water.

Keywords: rain-fed, irrigation, techniques, yield, growth

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1. INTRODUCTION

Cucumber (Cucumis sativus L.) is an important vegetable crop in the Cucurbitaceae family that has been cultivated by man for over 3,000 years (Adetula and Denton, 2003; Okonmah, 2011). It originated in Northern India and is widely distributed throughout the world (Remison, 2005). According to Akinwole et al (2019) the total world production of Cucumber as at 2017 was 83, 753, 861 tonnes, with China alone producing 77% of the world total (688,824, 643 tonnes) (FAO (2018). Egypt is the highest producer of cucumber in Africa (591, 858 tonnes as of 2017) but the current production in Nigeria is not available. Economically, it ranks fourth after tomatoes, cabbage, and onion in the tropical region (Eifediyi and Remison, 2009), and it's one of the most important marketed vegetables in the world (Ali & Khan 2016) Cucumber contains up to 90-95 percentages of water, contains silicon which helps to give strength and connecting tissue so helps to relief from joint pain. It also contains pinoresinol, lignans, secoisolariciresinol and lariciresinol that are helpful to reduce risk of different kinds of cancer (Mallick (2022). Other minerals are potassium, Sulphur, vitamins, sodium and acid creating materials which are helpful to make maintain the human blood alkalinity. According to Mallick (2022), the nutrients amount in 100g of cucumber is as shown in Table 1 below.

Table 1: Nutrients compounds in each 100 gm of Cucumber

Nutrients	Amount
Carbohydrates	2.6 gm
Protein	0.6 gm
Calcium	18 gm
Thiamin	0.02 mg
Energy	12 calories
Riboflavin	0.02 mg
Iron	0.2 gm
Vitamin	C 10 mg
Niacin	0.01 mg

Source Mallick (2022)

It has been argued that cucumber yield, height and weight are largely varied as this may be influenced by so many factors. For instance, Chinatu et al., (2017) reported a yield between 40, 178 and 63, 66 Kg/ha in Abia state, while Eifediyi and Remison (2009) reported a yield between16, 237 and 43, 259 Kg/ha in Edo State, Nigeria (Akinwole et al 2019). It has been further reported that cucumber cultivation is limited mostly to the raining season, where water is abundance from April to October than in the dry season (November to March). This is because cucumber needs a plentiful amount of water for its growth. In the regions with low annual rainfall, irrigation becomes a necessity for crop production. Even in areas with sufficient seasonal rainfall,

irrigation becomes essential during the dry season as more food needs to be produced for the teeming population (Yaghi et al. 2019).

Several reasons have been forwarded for the adoption for of either rain or irrigation water for the production of cucumber in Nigeria. According to Zakka et al (2020) water, conservation and maximizing its use for irrigation is crucial for sustainable economic production of vegetable and other irrigable crops. Limited water for crop production makes growers seek ways to save water by increasing irrigation efficiencies. While rain falls naturally, irrigation is carried out with difference sources of water be it pipe born, borehole or even waster or grey waste. Whatever the case, it is an artificial way of water application which involves the use of watering can or conveying water under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants.

In recent times, farmers especially small holder farmers have increasingly embraced irrigation watering system in their cucumber cultivation for almost all-year- round production and also to enhance income and livelihood conditions, rather than cultivating cucumber only during rainy season. In most cases, leaching of nutrients in the soil while cultivating cucumber in dry season is minimized and there are lesser incidences of disease and pest infestations.

With the event of climate change and its consequences through high temperature, cessation and excess of rainfall and high evapotranspiration among others, there is inconsistence in the cucumber cultivation in most part of the tropical region. The situation is becoming more unpredictable as sporadic precipitation, in addition to long dry spell are limiting water supply during cucumber growing season and causing rising cost of production (Adetula and Denton, 2003). In some cases, dry season is longer while rain season becomes shorter than is planned for. Cucumber cultivators thus face a number of challenges including pest and disease infestation due to inadequate water supply, high temperature and inconsistencies in the average weather conditions for bountiful harvest and low cost of production. This condition may disrupt cucumber availability, reduce access and equally affect the quality of cucumber.

With the increasing food insecurity experiences in Nigeria especially as it is associated with poor diet, not enough food available, low intake of nutritious, and lack of access of nutritious food like cucumber, the need to increase ways of improving cucumber availability has become very important. Empirical information on a comparative cultivation analysis is critical if any positive breakthrough can be achieved (Khanal et al.2020; FAO, 2006).

To meet up with the growing need of the population therefore, an understanding of the efficient growth and yield of different cucumbers water consumption level during its growth cycle is needful. This is because factors such as types of cucumber plant, climatic conditions, soil moisture, soil types and soil porosity, and

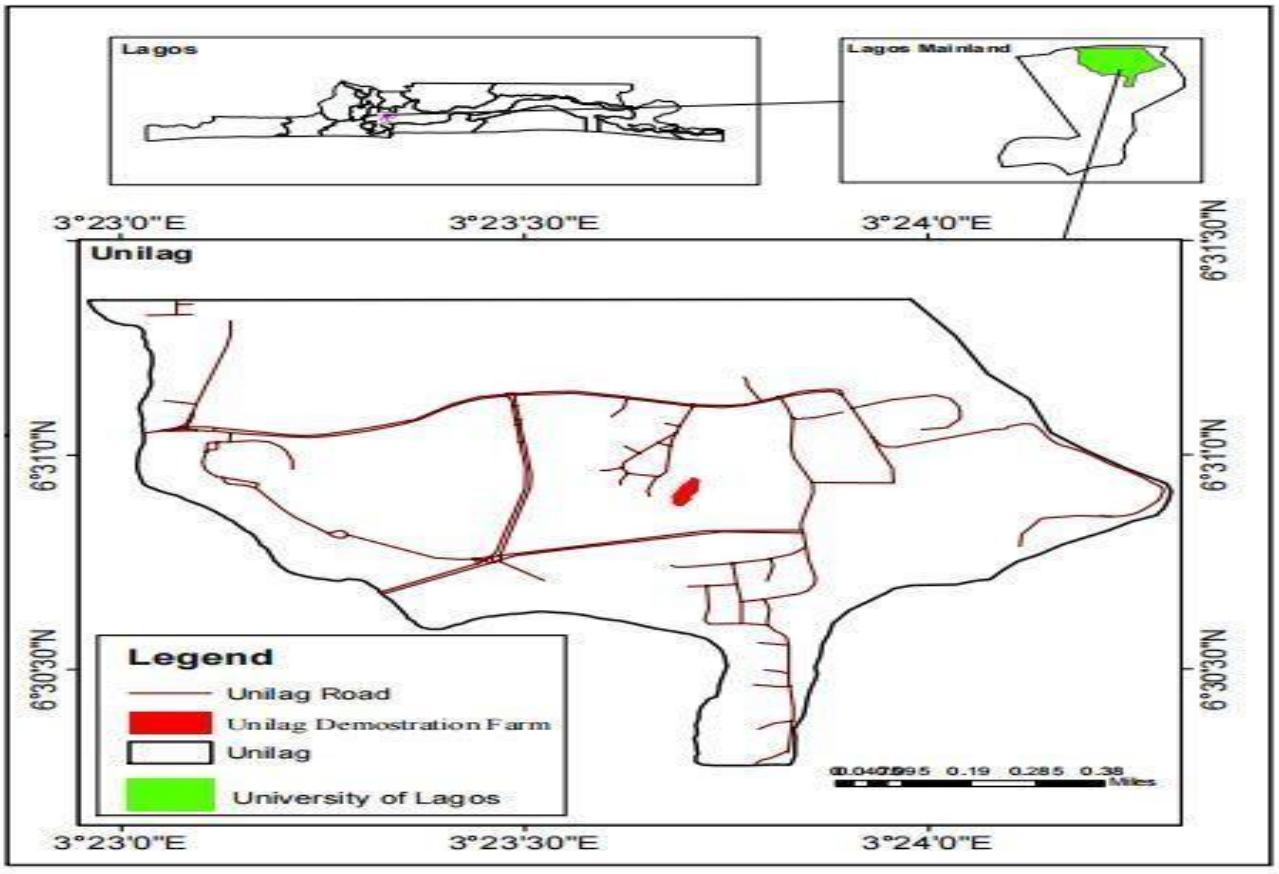
root distributions as well as water uptake by plants play important role in making water available for either rainfed or irrigation plants. Focusing on the efficient use of water is thus increasingly significant relevant research interest (Mao et al., 2003), so as to improve water use management under conditions of best practices for cucumber growth, yield and weight (Assouline, 2002). Thus, this research is aimed at comparing the influence of precipitation (rain) and irrigating technique on the yield of cucumber cultivation. Specifically, it is meant to estimate the growth rate of cucumber plants of rain-fed and irrigated beds and further estimate the number of harvested cucumber fruits per plant. The paper is also meant to provide answers to the following questions: what is the growth rate of cucumber plant of the rain-fed and the irrigated? how many cucumber fruits can be harvested per plant from the rain-fed and irrigated beds? What is the weight of each cucumber fruit harvested from the rain-fed and the irrigated?

2. Methodology

Experimental Site

The experiment was carried out at the Geo-Demonstration farm of the Department of Geography, University of Lagos, with coordinates of between 6.455027°N 3.384082°E (see Figure 1). The climate of the experimental site is similar and consistent with the rest of Lagos metropolis which is tropical in nature, and characterized averagely by longer wet and shorter dry seasons.

Figure 1.1: Map of University of Lagos showing the Demonstration Farm of the Geography



The temperature in the study area ranges between 21°C and 34°C while the annual rainfall ranges between 150 mm and 3000 mm. This site experiences a dry season (when it rains less than two days per month) during August and September, as well as between December and March. The vegetation of the site is made up of freshwater swamps and mangrove forests (Cao et al. 2003).

According to Akinwole et al (2019), cucumber requires a warm climate with optimum day temperature requirement of 30ºC, and optimum night temperature of 18-21ºC. It requires fertile soil with good amount of organic matters, well-drained with a pH of 6.0-7.0. It also needs, potassium, phosphorus, calcium and magnesium (in the proportion 1: 0.75: 0.13: 0.09: 0.09, respectively). It prefers nitrates as nitrogen source with optimal concentration of nitrogen in the solution is 200 to 300 mg/L. Fruits can be harvested 1-2 weeks after flowering (Abegunrin, et al (2013). All these requirements were considered in the study.

Source of Data

Both primary data and secondary data were used for this research study. For secondary data, meteorological data on rainfall during the period (July and August 2021) were collected in addition to the collection of relevant and related literature on rainfed and irrigated vegetables production. The rainfall data was needed to determine the volume of rain that the cucumber received during the experiment. Harvesting of fruits was done after seven weeks. For primary data, field experiment involving two experimental samples, one for rain-fed and the other for fresh water/borehole water were carried out at the Geo-demonstration farm. The following activities were also carried out:

Activity one: Preparation and planting of Cucumber

Preparation of grow bags were done with 6 for rain fed and 2 for irrigation. Filling of the grow-bags with enough loamy soil was done with a mixture of poultry manure on the rain-fed and the irrigated (grow bags). The grow bags for rain-fed and irrigation samples water labelled A and B respectively. Cucumber seeds were planted in each of the bags with at 100cm depth and a total of 8 growbags. Water from the borehole was used for irrigation water while the other sampled grow bags depended on the rain water. The sample B was protected from rain but was positioned in such a way that it can receive adequate sunshine. The watering commenced two weeks after propagation for sample B while sample A were not irrigated. Growing of the cucumber started a week after and staking was done for easy climbing.

Activity Two: Recordings, Measuring and Application of input

The growth characteristics of the sampled cucumber plants were measured using parameters including; plant height (cm), number of leaves, and fruit weight (g). Lengths, heights and diameters were measured using a flexible tape and the fruits were weighed using a sensitive scale, the number of leaves was assessed by a visual count of the green leaves. Cucumber fruits were harvested at maturity between 6 and 7 weeks after sowing. Super-glo and neem oil were applied weekly as nutrients and prevention of pest using standard measures and methods weekly:

Data Analysis

Descriptive statistical tools such as mean and standard deviation, table, charts i.e., bar graphs and percentages were employed, while independent sample t-test was used to test the significant difference in the height and weight parameters that were measured for the rain-fed and irrigated cucumber plants.

4. DATA PRESENTATION AND ANALYSIS

The Quantity of Irrigated and Rain Water applied on Cucumber

Estimating the quantity of water applied for this experiment is significant because water is relevant for a number of plant activities. Water enables photosynthesis which is how plants use energy from sun to create food. Through water absorbent in production process cucumber plant is able to use carbon dioxide from the air and hydrogen to release oxygen as a by-product. It enables plants cell turgidity for structure and growth, transport nutrients and organic compounds.

Using FAO conversion of cubic millimetre (1 mm to 1 litre) for the seven weeks experiment therefore, an average of 9.4mm and 14.5mm of rainfall were estimated to have been received by the cucumber plants for three weeks in July and four weeks August 2021 respectively. While an average of 21mm of borehole water and 28 mm of water were applied for irrigation in three weeks in July and four weeks in August 2021(see Table 2). The finding differs from Zakka et al. (2020) presentations which stated that cucumber plants need between 25 mm and 50 mm of water per plant per week for optimum production and fruit quality. The plants have higher demand for moisture during pollination and fruit development.

Table 2: **The Quantity of irrigated and rain water applied on Cucumber**

Experiment	**Avg. Mini. water Received (July)**	**Avg. Maxi water Received (August)**	**Number of Cucumber plant**
A-Rain-fed Cucumber	9.4mm	14.5mm	6
B-Irrigation fed Cucumber	21mm	28mm	2

Source: Field Survey, 2021.

Note: I cubic millimetre equals 1 litre of water

Comparison of the heights of cucumber plants on the rainfed and irrigated beds

The result further revealed as depicted on Table 3 that the height of the sampled cucumber cultivated, progressively increase every week from 27 cm to 189cm for the rain-fed and from 26cm to 189.4cm for the irrigated cucumber plants. The average increase in the height of rain-fed and irrigated cucumber per week was 5.2 cm and 4.3 cm respectively. In order to determine the statistical significance in the weekly height of the rain-fed and irrigated cucumber, the t-test results revealed that there is no significant difference between height of the rain-fed and irrigated cucumber as the P-value was found to be 0.192 was greater than 0.05 (PV=0.192 >0.05).

Table 3: Height of the Sampled cucumber of rainfed and irrigated plants

Technique	**No cucumber sampled**		***Wk 1***	***Wk 2***	***Wk 3***	***Wk 4***	***Wk 5***	***Wk 6***	***Wk 7***
Rainfed Beds	**Six (6)**	**A**	28.5 cm	55.0 cm	80.6 cm	120.0 cm	149.4 cm	178.6cm	190.1 cm
		B	28.0 cm	50.5 cm	77.3 cm	-	-	-	-
		C	26.5 cm	54.2 cm	79.5 cm	119.0 cm	147.4 cm	176.5cm	188.7 cm
		D	27.9 cm	51.0 cm	81.5 cm	120.1 cm	-	-	-
		E	28.4 cm	55.0 cm	79.5 cm	119.6 cm	147.0 cm	176.6cm	187.5 cm
		F	26.7 cm	55.9cm	80.0 cm	120.4 cm	149.0 cm	178.0 cm	190.7 cm
		Avg height	***27.5 cm***	***53.5 cm***	***79.6 cm***	***119.8cm***	***148.2 cm***	***177.4 cm***	***189.3 cm***
Irrigated Beds	**Two (2)**	**A**	26.3 cm	50.0 cm	78.0 cm	113.8 cm	138.0 cm	167.2 cm	189.4 cm
		B	26.0 cm	49.5cm	79.1cm	112.3 cm	137.1 cm	166.6 cm	188.9 cm
		Avg height	***26.2 cm***	***49.8 cm***	***78.5 cm***	***113.1 cm***	***137.5 cm***	***166.9 cm***	***189.2 cm***

Source: Field Survey, 2021.

Number and Weight of Cucumber Fruits Harvested from Rain-fed and Irrigated plants

The study further revealed that rainfed cucumber plants yielded more fruits than the irrigated cucumber plant as shown on Table 4. The average fruits from rain-fed cucumber plants was 3.3, while that of the irrigation was found to be 2.0. This implies that the weight of the harvested cucumber fruits from the rainfed grow bags exceed the weight of the harvested fruits from the irrigated beds. The high number of, and weight of rain-fed cucumber may be associated with enrichment of rain water with micro nutrients from the atmosphere, although it is also believing that rainwater is the purest of all waters. However, studies have pointed higher Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sodium in rainwater. The limited number of fruits harvested from the irrigated cucumber plant might be also be attributed to different physiochemical

characteristics of the sources of the bore hole water, depending on the source from which is it collected. For example, water collected from chalky areas will be hard and contain a lot of dissolved calcium or other micro nutrients which may be problematic and even injurious to some plants.

Table 4: Number and Weight of Cucumber Fruits Harvested from Rain-fed and Irrigated plants

Techniques used	**Grow bags**	**Number ofharvested Fruits**	**Weights of harvested fruits** (kg)
Rainfed bag	**Bag 1**	4	1.56
	Bag 2	3	1.19
	Bag 3	3	1.23
	Bag 4	4	1.00
	Bag 5	4	1.3
	Bag 6	3	1.1
	Total	***21***	***7.38***
	Average	***3.33***	***1.33 kg***
Irrigated bags	**Bag 1**	2	0.50 kg
	Bag 2	2	0.40 kg
	Total	***4***	***0.9 kg***
	Average	***2***	***0.53 kg***

Source: Field Survey, 2021.

This showed that the yield and weight of cucumber decreased with the application of irrigated water when compared with that with rainfed plant, implying that there might be the likelihood of in adequate water application or withholding water below what the plant is needed which has the tendency to reduce the yield. In another perspective, the shade provided to prevent the experiment to receive rainfall could alter the level of other important environmental functionality and the appropriate need of the irrigated cucumber. This could also imply that the cucumber crop evapotranspiration might be reduced with limited or shaded interaction with the environment which can promote moisture stress that can affect stomatal openings of a plant, mainly causing a closure in stomata which in turn slows the rate of transpiration (Michael ,2009; SAO.,2019).

Deficit in irrigation mode and process has also been argued to influence the immediate root zone of the plant that is wetted (Pal et al. 2020; Mao et al.2003). Another point of consideration that can affect the poor performance of irrigated cucumber cultivation could be irrigation interval which can be a very crucial in plant

management as it affects soil moisture and root distributions as well as water uptake by plants. Li and Wang (2000), have indicated that irrigation frequency can change the spatial distribution of soil moisture and soil-water storage. Low frequency irrigation corresponds to excessively long irrigation intervals and may cause moisture stress, especially in sandy soil textures (Uçan et al 2007, Ting et al1999).

The small weighted nature of the irrigated cucumber can also be attributed to inadequate understanding of the right amounts of water needed for plants during the growth cycles, and to develop the most suitable irrigation schedule to produce the optimum plant yield. This is because irrigation scheduling involves preventing the soil water deficit from falling below some threshold level for a particular crop and soil condition. This according to Zakka et al (2020), the situation may involve estimating the earliest date to permit efficient irrigation or the latest date to avoid the detrimental effects of water stress on the crop. Such schedules are developed for different ecological regions, as plant water consumption during the growth cycle depends mostly on plant growth, soil and climatic conditions (Nega., 2009; Zhang et al. 2019) Scheduling water application is very critical to make the most efficient use of irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production.

5. Conclusion

This study reveals the yield, growth and output of cucumber plants using rainfed and irrigation techniques. The rainfed technique was found to be more viable for high yield, growth and height than the irrigation technique because rainfed cucumber was believed to have natural micro nutrients and also have direct relationship with sunlight, unlike the irrigation techniques which demands manual watering. Water stress, deficiency and improper frequencies could explain the factors that played down the response of the cucumber plant using irrigation techniques. The study further revealed that poor irrigation practices in addition to inconsistencies in understanding cucumber water need and application could have enables better yield and weight of the cucumber. Therefore, the following research areas are recommended in order to have adequate irrigation technique application for maximum yield, growth all year round to support farmers livelihood conditions and enhance food security. There should be more experimental research focus:

- on the viability of water sources needed for irrigation in the tropical and subtropical region
- on the response of cucumber cultivation to regional soil permeability and water percolation characteristics
- Irrigation application water efficiency analysis for cucumber production

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