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Influence of irrigation interval and water quantity on the performance of sack grown cucumber (*Cucumis sativum*) in Bauchi State, Nigeria

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ABSTRACT

A field experiment was conducted at the teaching and research farm of Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi during dry season of 2025 to study the influence of irrigation interval and water quantity on the performance of sack grown cucumber. The treatments consisted of four (4) irrigation intervals (1, 3, 5 and 7 days) and three (3) quantities of irrigation water (1, 2 and 3 litres). These were factorially combined to give 12 treatments and laid out in a randomized complete block design (RCBD) with 3 replications. Data were collected on plant height (cm), number of leaves, stem diameter (cm), leaf area (cm^2), number of fruits and fruit yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted to separate significantly different treatment means. The result of the experiment indicated that there was significant ($P \leq 0.05$) difference among the treatments used. The result further revealed that, irrigation interval of one (1) and three (3) days significantly ($P \leq 0.05$) produced the higher growth and yield response of cucumber throughout the sampling period. Water quantity on the other hand, application of three (3) liters significantly ($P \leq 0.01$) performed better in all the parameters observed than the other quantities used throughout the study period. Based on the result of this finding, 1- and 3-days irrigation intervals and 1 to 3 liters of water influenced higher performance of cucumber and are recommended for optimal productivity of the crop.

Keywords: cucumber, irrigation, interval, sack, performance

1. INTRODUCTION

Cucumber (*Cucumis sativus*) is an important crop which is widely cultivated in different agro-ecologies of Nigeria. As a warm-season crop, cucumber requires specific environmental conditions to thrive, with adequate water supply being one of the most critical factors for its successful cultivation (Nwite-Eze 2023). It is one of the oldest vegetable crops grown for at least five thousand years (Okonmah, 2011). The crop is cultivated in most parts of Northern Nigeria and some parts of Eastern Nigeria by peasant farmers. The fruit varies in shape, size and color. The fruit also

serves as remedy in the treatment of constipation, jaundice and indigestion (Akpan and Okamigbo, 2019).

Demand for vitamins and minerals are highly dependent on vegetables. Cucumber and other fruit and leafy vegetables are in high demand because of their nutritional and economic values. Cucumber production has the capacity to enhance agricultural production, economic empowerment and food security. They are consumed fresh, as desserts in after meals, juice or in combination with other food materials. Its production continues to gain attention in Nigerian communities because of their nutritional and economic values. Average yield per/ha is below world average (Oriuchukwu and Amadi, 2022). Cucumber production in Nigeria is majorly for local consumption, although Nigerian cucumbers are sometimes exported to neighboring countries of West Africa like Chad, Cameroun, Niger and Benin Republics. Due to its importance, it ranks among major horticultural crops cultivated in Nigeria. Others are citrus, mango, African star apple, watermelon, banana, avocado pear and pineapple rank among major crops in Nigeria. Like most vegetables, its production is profitable due to high amount of income per unit area compared to some other crops. Cucumber production in Nigeria is usually under small scale production. Although commercial (large scale) production is also practiced under plantation farming. Some factors limiting the productivity of Nigerian soils for cucumber production include low fertility, slope and poor effective depth and stoniness or high gravel content and low nutrient or moisture retention. Good agronomic practices such as regular weeding, timely irrigation, fertilizer application and prompt harvesting are necessary for the attainment of high yield and production of quality fruits. Cucumbers are planted year-round. They can be directly seeded or transplanted. The growing of vegetables like cucumber can result in high yield even on small farm land (Adekiya *et al*., 2022). During the wet season, rainfall may be sufficient to support cucumber growth, but during the extended dry season, water becomes a limiting factor. Climate change has exacerbated this issue, with increasing unpredictability in rainfall patterns, leading to more frequent periods of drought and water stress (Akpan and Okamigbo, 2019). Understanding these responses will allow farmers to implement more efficient water use strategies, reducing crop losses and ensuring sustainable production (Basel and Sami 2014).

Water is an essential factor in agricultural production all over the world. 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. A major constraint to arable crop production is the availability of water, water often Nigeria, an abundant supply of water is not available during the dry period (typically from November to April), and hence 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 according (Zakka *et al*., 2020). As a key crop for smallholder farmers, cucumbers provide both nutritional and economic benefits to local communities. However, the crop's sensitivity to water stress means that even short periods of drought can result in significant yield losses, affecting both food security and farmers' incomes (Geerts and Raes, 2009). Given the projected increase in water scarcity due to climate change, there is an urgent need to develop more efficient water management practices for cucumber cultivation (FAO, 2022). This study will contribute valuable insights into the specific water needs of cucumber plants under the environmental conditions of the study area. By providing data on how cucumbers respond to different levels of water stress, the study will help local farmers make appropriate decisions about water use, improving the sustainability of cucumber production in the area. Additionally, the study's recommendations on water management strategies will be directly applicable to other semi-arid regions facing similar challenges with water scarcity. This research was therefore aimed to investigate the growth response of sack grown cucumber to varying irrigation intervals and water quantity in Bauchi State, Nigeria.

2. MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the teaching and research farm of Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi state, Nigeria. The site is located at latitude 10°22 N; 9°47 E and 1300 m. above sea level.

Experimental Materials and their Sources

The materials used in the study includes: cow dung, loamy sand, sandy soil, sacks, thread, sticks, water and cucumber seed. The cucumber seed was sourced from Plateau State Agricultural Development Programme (PADP) Jos, plateau state. Fertile soil was collected from the research farm of the Department of Crop Production Faculty of Agriculture and Agricultural Technology of Abubakar Tafawa Balewa University Bauchi state. Fine sand was obtained from the hostel block within the school campus and the

organic manure (cow dung) was collected from the school animal farm. The sacks were purchased from Muda lawal market in Bauchi town.

Treatments and Experimental Design

The treatments consisted of four (4) irrigation intervals (1, 3, 5 and 7 days) and three (3) quantities of irrigation water (1, 2 and 3 litres). These were factorially combined to give 12 treatments and laid out in a randomized complete block design (RCBD) with 3 replications.

Preparation of Growing Medium

Fine sand was obtained from the hostel block within the school campus and the organic manure (cow dung) was collected from the school animal farm. The top soil, fine sand and organic manure was mixed and measured into the sacks at the ratio (1:2:1) with top soil having the highest ratio of 2, while fine sand and organic manure having equal ratios of 1. Two cucumber seeds were sown to a depth of 1-2cm and 35cm apart from each other in each of the sacks.

Cultural Practices

Weeds were removed by hand pulling during the processes of watering and data collection, appropriate insecticides and disease control chemicals were applied at the incidence of both disease and pests. The inorganic fertilizer recommended for cucumber was applied at four and six weeks after emergence. The cucumber was harvested by hand picking the matured ones from the plant.

Data Collection

Data were collected from the randomly tagged plants at weekly intervals starting from 4 weeks after sowing (WAS) on Plant height (cm), Number of leaves**,** Stem diameter (cm), Leaf area (cm^2), Number of fruits per plant and Fruit yield.

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) to test the level of significance of all the treatment. Duncan's Multiple Range Test (DMRT) was however adopted during the analysis to separate significantly different treatment means.

3. RESULTS & DISCUSSION

Plant Height

Result in Table 1 showed that Irrigation interval and water quantity significantly affected plant height throughout the sampling period. For all the stages, the tallest plants were obtained when plants were irrigated daily (1 day) and with 3 liters of water application. It follows that the shortest plant heights were under irrigation intervals of 5 and 7 days with 1-liter of water supply. The significant effect of irrigation interval and water quantity on plant height as observed in this study showed that water availability is key to the growth of cucumber plants. Optimum water is required to ensure turgor pressure within the cell, which acts as the force for elongation. Results showed the tallest plants were from treatments that had 1-day irrigation with 3-liters of water application, and this would mean that a frequent supply of water favors best vegetative growth. This is in accordance with the findings of (Bala *et al*., 2022).

Number of Leaves

According to Table 2, irrigation interval and water quantity both had significant effects on the number of leaves at 8 and 10 WAS. A higher frequency of irrigation interval of 1 and 3 days resulted in more leaves, particularly at 8 and 10 WAS. 3 liters also significantly produced the highest number of leaves at 6, 8 and 10 weeks after sowing.

The significant effects of irrigation interval and water quantity on number of leaves as observed in this study signified that water promotes the development of leaves. Water plays an important role in the expansion and growth of leaves and new leaf emergence, adjusting the conductance and photosynthesis of stomata. Plants irrigated at an interval of either once a day or every 3 days with 3 liters of water recorded the highest number of leaves, especially at 8 and 10 WAS. This is in agreement with those of (Yuqi *et al*., 2019), who established that well-watered plants develop more leaves because of their higher photosynthetic activities. On the other hand, plants that received longer irrigation intervals with lower water volumes showed fewer leaves, which could be a consequence of restricted water availability to the plant for leaf production. Sack farming depends largely on frequent irrigation with satisfactory water supply to enhance leaf growth, since small volumes of soil can quickly impose water stress on a plant.

Table 1. Effect of Irrigation Interval and Water Quantity on Plant Height (Cm) of Cucumber Grown in Sack

Treatments	Weeks After Sowing			
	4 WAS	6WAS	8WAS	10WAS
Irrigation interval (Days)				
1 day	12.500^{ab}	20.942^{a}	32.208^{a}	35.417^{a}
3 days	14.242^{a}	20.833^{a}	25.333^{b}	29.667^{b}
5 days	8.958^{b}	16.542^{ab}	20.217^{c}	24.500^{c}
7 days	9.875^{ab}	14.242^{b}	18.500^{c}	21.583^{c}
LS	**	*	**	**
SE ±	1.488	1.716	1.350	1.265
Water quantity (Littre)				
1	10.275	15.738	20.469^{c}	23.188^{c}
2	10.413	18.806	24.000^{b}	27.875^{b}
3	13.494	19.875	27.725^{a}	32.312^{a}
LS	NS	NS	**	**
SE ±	1.289	1.486	1.169	1.096
Interaction				
I x W				
LS	NS	NS	NS	NS

Means followed by different letters are significantly different using DMRT, Significant difference: * = significant at 0.05, ** = significant at 0.01, NS: Not significant, LS: Level of significance, SE±: Standard error, WAS: Weeks after sowing.

Table 2. Effect of Irrigation Interval and Water Quantity on Number of Leaves of Cucumber Grown in Sack

Treatments	Weeks After Sowing			
	4 WAS	6WAS	8WAS	10WAS
Irrigation interval (Days)				
1 day	8.167	12.750	25.667^{a}	28.917^{a}
3 days	7.250	12.000	19.000^{b}	23.167^{b}
5 days	5.583	9.083	13.667^{c}	17.833^{c}
7 days	6.333	8.833	13.417^{c}	17.583^{c}
LS	NS	NS	**	**
SE ±	.879	1.370	1.700	1.245
Water quantity (Littre)				
1	6.188^{a}	8.500^{b}	14.188^{b}	17.438^{c}
2	6.500^{a}	10.687^{ab}	17.938^{ab}	21.813^{b}
3	7.812^{a}	12.812^{a}	21.687^{a}	26.375^{a}
LS	NS	**	**	**
SE ±	.761	1.186	1.472	1.079
Interaction				
I x W				
LS	NS	NS	NS	NS

Means followed by different letters are significantly different using DMRT, Significant difference: * = significant at 0.05, ** = significant at 0.01, NS: Not significant, LS: Level of significance, SE±: Standard error, WAS: Weeks after sowing.

Table 3. Effect of Irrigation Interval and Water Quantity on Stem Diameter (Cm) of Cucumber Grown in Sack

Treatments	Weeks After Sowing			
	4 WAS	6WAS	8WAS	10WAS
Irrigation interval (Days)				
1 day	2.492[a]	3.533[a]	4.450[a]	4.817[a]
3 days	2.617[a]	3.217[a]	3.408[b]	3.733[b]
5 days	1.992[b]	2.700[b]	2.933[c]	3.167[c]
7 days	1.908[b]	2.433[b]	2.692[c]	2.983[c]
LS	**	**	**	**
SE ±	.148	.142	.140	.164
Water quantity (Littre)				
1	2.106	2.563[b]	2.894[b]	3.113[c]
2	2.188	3.062[a]	3.456[a]	3.712[b]
3	2.462	3.288[a]	3.762[a]	4.200[a]
LS	NS	**	**	**
SE ±	.129	.123	.121	.142
Interaction				
I x W				
LS	NS	NS	NS	NS

Means followed by different letters are significantly different using DMRT, Significant difference: * = significant at 0.05, ** = significant at 0.01, NS: Not significant, LS: Level of significance, SE±: Standard error, WAS: Weeks after sowing.

Table 4. Effect of Irrigation Interval and Water Quantity on Leaf Area (Cm^2) of Cucumber Grown in Sack

Treatments	Weeks After Sowing			
	4WAS	6WAS	8WAS	10WAS
Irrigation interval (Days)				
1 day	57.808[a]	106.150[a]	124.825[a]	134.292[a]
3 days	72.125[a]	92.033[a]	101.400[b]	116.342[b]
5 days	36.958[b]	53.492[b]	74.508[c]	91.942[c]
7 days	30.317[b]	44.192[b]	60.592[c]	75.742[d]
LS	**	**	**	**
SE ±	7.145	7.896	5.851	5.474
Water quantity (Littre)				
1	41.631	53.375[b]	70.838[c]	84.219[c]
2	46.344	58.488[b]	89.738[b]	105.513[b]
3	59.931	91.037[a]	110.419[a]	124.006[a]
LS	NS	**	**	**
SE ±	6.187	6.838	5.067	4.740
Interaction				
I x W				
LS	NS	NS	NS	NS

Means followed by different letters are significantly different using DMRT, Significant difference: * = significant at 0.05, ** = significant at 0.01, NS: Not significant, LS: Level of significance, SE±: Standard error, WAS: Weeks after sowing.

Table 5. Effect of Irrigation Interval and Water Quantity on Reproductive Parameters of Cucumber Grown in Sack

Treatments	Number of Fruits per Plant	Fruit Yield per Plant
Irrigation interval (Days)		
1 day	1.250[a]	125.833[a]
3 days	1.167[a]	106.667[ab]
5 days	.917[a]	81.417[b]
7 days	.500[b]	43.833[c]
LS	**	**
SE ±	.123	10.392
Water quantity (Littre)		
1	.563[c]	50.375[c]
2	1.000[b]	91.062[b]
3	1.312[a]	126.875[a]
LS	**	**
SE ±	.106	9.000
Interaction		
I x W		
LS	NS	NS

Means followed by different letters are significantly different using DMRT, Significant difference: * = significant at 0.05, ** = significant at 0.01, NS: Not significant, LS: Level of significance, SE±: Standard error, WAS: Weeks after sowing.

Stem Diameter

The result as presented in Table 3 showed that, the variation in irrigation interval and water quantity of the plants had a significant effect on the diameter of the stem throughout the experimental period. Plants irrigated daily with 3 liters of water developed the thickest stems, while those plants with more prolonged intervals and reduced volume of water had the smallest diameter. This result indicated that irrigation interval and water quantity are highly influential on stem diameter, hence the availability of water is very important at the stages when the stem of a plant is developing. Thicker stems provide better structural support and make it easier to transport water and nutrients internally. The thickest diameter was obtained in those plants that were subjected to daily irrigation with a volume of 3 liters of water; longer intervals with less volume resulted in thinner stems. It is supported by the work of (Alarima *et al*., 2022), who showed that proper irrigation keeps the turgor pressure in the cells of the stem, resulting in thickening of the stem. Since sack farming limits the plants in terms of root space and water retention, frequent irrigation is very important in order for the plants to develop strong stems that support the growth of the plants as well as their fruits.

Leaf Area

Table 4 presented result of the influence of irrigation interval and water quantity on leaf area of cucumber. The result showed that, leaf area was indeed influenced by irrigation interval and water quantity. That means the highest leaf area was recorded under a daily irrigation regime with a water quantity of 3 liters compared to longer irrigation intervals and smaller water quantities of 5 and 7 days, respectively. Leaf area is one of the major determinants of photosynthetic capacity. Irrigation interval and water quantity significantly affected leaf area. The largest values of leaf area were assessed in the plants treated with a daily irrigation frequency with 3 litres of water, whereas for the other plants irrigated less frequently with less water the leaf area was significantly smaller. This agrees with the work of Okee *et al*. (2020), who also noted that a larger leaf area is related to good water supply due to the limiting role of water stress on cell expansion, thus generally negative to leaf growth. Sack farming should ensure maximum leaf area so that the plants receive sufficient sunlight for photosynthesis. It, therefore, follows that frequent irrigation with considerable volumes of water has to be practiced in sack farming to promote large leaf areas in the reduced growing environments.

Number of Fruits Per Plant and Fruit Yield Per Plant

Result as presented in Table 5 revealed that, irrigation interval and water quantity significantly influenced the number of fruits per plant and yield of fruits per plant. higher number of fruits and yield was recorded with daily irrigation interval with 3 liters of water, while plants under longer irrigation intervals with smaller water quantity produced less fruits and lower yields.

The highly significant influence of irrigation interval and water quantity on the reproductive parameters as observed in this study, including fruits per plant and fruit yield per plant, pointed out that water availability during the reproductive phase is very important. Highest fruit yield came from daily irrigation with 3 liters of water, while lower yields were considered highly significant for plants with longer irrigation intervals and with smaller water volumes. This finding is in agreement with the work of Bala *et al*. (2022), who found that proper irrigation during the reproductive stage significantly enhances the fruit production of cucumber. Due to the poor water retention in sack farming, continuity of water supply is required during fruiting for attaining high yields. It means that both high water volume and frequent irrigation are needed to give an optimum yield of cucumber crops using confined growing systems.

4. CONCLUSION

The clear trend from the results indicated that in cucumber sack farming systems, a higher frequency of irrigation and sufficient water supply are required for optimal growth and yield. Most of the growth and reproductive parameters were significantly influenced by both irrigation interval and water quantity, underlining the importance of the role of water management in confined growing environments. Sack farming is a system with very limited soil volume, so more precise and continuous watering is required to avoid any water stress to obtain the best performance from the plants. Irrigation at a 1-day interval with 3 liters of water per application gave the optimum growth and yield of cucumber. Under the sack farming system, more frequent irrigation is recommended, since the plants are under severe stress due to limited root space.

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Author Contributions

Shuaibu, Yunusa Muhammad, research design, supervision and manuscript preparation.
Bala, Rashida Abdulmumini, supervision and data analysis.
Nuruddeen, Muhammad, data collection and validation.

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Conflict of interest

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

In this article, as per the plant regulations followed in the Department of Crop Production, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria; the authors observed the influence of irrigation interval and water quantity on the performance of sack grown cucumber (*Cucumis sativum*) in Bauchi State, Nigeria. The ethical guidelines for plants & plant materials are followed in the study for observation, identification & experimentation.

Informed consent

Not applicable.

Data availability

All data supporting the findings of this study are embedded within the manuscript.

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