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Research Article

Performance of Cucumber in Hydroponic Solutions with Varied Nutrients Concentrations Using Rice Husk as Root Anchor

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Abstract

Background and Objective: The concentration of the nutrient solution is a crucial factor that impacts plant growth in hydroponic and soilless agriculture. The primary objective of this study was to examine the influence of varying nutrient solution concentrations and different plant varieties on the growth and yield of cucumbers. **Materials and Methods:** This investigation was conducted at the Department of Crop Horticulture and Landscape Design Experimental Farm of Ekiti State University, Ado Ekiti. The soilless cultivation was executed between March, 2022 and May, 2022. The experimental design was arranged in a Completely Randomized Design (CRD), consisting of eight treatment combinations (two varieties and four nutrient concentrations) that were replicated 4 times. **Results:** After weeks of transplanting, no significant difference was observed among the four nutrient concentrations employed. In terms of all the growth parameters, including fruit length, fruit girth and fruit weight, there was an increase in values as the concentration of nutrient solution increased. However, no significant statistical difference was observed, except for the number of fruit and flowers, where a significant difference was observed. Moreover, it was observed that variety 1 outperformed variety 2 in all parameters considered. **Conclusion:** It can be inferred that cultivating crops through soilless cultivation will contribute to fulfilling the nutritional needs of humanity in regions where the native soil does not facilitate plant growth.

Key words: Cucumber, hydroponics solutions, soilless farming, rice husk, root anchor, food security

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Vegetables are an indispensable component of the human diet as they serve as major sources of vitamins and minerals necessary for human health. Cucumbers (*Cucumis sativus*) and other vegetables are in high demand owing to their nutritional and economic values. Belonging to the family Cucurbitaceae, cucumbers are creeping vegetables that are widely sought after[1]. Due to their short growing cycle and high economic value in off-season production[2].

From a nutritional perspective, cucumbers represent an exceptional source of phytonutrients, such as flavonoids, lignans and triterpenes, endowed with antioxidant, anti-inflammatory and anti-cancer properties[3]. In Nigeria, as in most African countries, as documented by Sepehri and Sarrafzaddeh[4], soil is the primary medium for planting because it provides support, nutrients, air, water and successful cultivation. However, soil production poses a significant challenge to crop production by producers due to numerous issues, such as pest and disease infestation, inadequate arable land, climate change declining productivity, and weed interference[5]. These constraints can create a serious challenge to the availability of many crops, including cucumber. Therefore, it is imperative to find an alternative way of circumventing these challenges and hydroponics/soilless farming is one such approach.

According to Tüzel *et al.*[6] soilless agriculture denotes a methodology of cultivating plants without soil as a rooting substrate, where the essential nutrients required for plant growth are supplied through irrigation water. This method has found widespread application in protected agriculture to enhance growing conditions and provide an optimal supply of water and nutrients to crops. Soilless cultivation has the potential to revolutionize cropping systems by optimizing the utilization of inputs like nutrients, pesticides and water, more efficiently managing diseases and enabling crop production to increase irrespective of prevailing climatic conditions[7]. Soilless culture could eliminate the dependency on methyl bromide, increase total yields and facilitate off-season production of several crops, such as strawberries[8].

Sequel to research, it was discovered that vegetables cultivated through hydroponics may undergo biofortification, and the nutrient content of juvenile leafy greens such as basil, mizuna, tatsoi and endive that are raised in soilless culture can be elevated without compromising crop yield and commercial viability[9]. Furthermore, soilless cultivation techniques have been efficaciously employed in introducing novel cultivars to a particular locality. Al-Karaki and Othman[10], as demonstrated by the successful growth of medicinal and aromatic herb species in an arid region (Middle-East nations).

According to estimates, roughly fifty-five percent of Africa's land is unsuitable for agricultural development. In a study by Eswaran *et al.*[11] only about 11% of agricultural land has high-quality soil that can be successfully managed to support more than twice the current population across many countries. As a result, a sizable portion of agricultural land has an average or low potential, with at least one major setback for agriculture and the rate of soil fertility has decreased drastically over the years.

Given all the constraints associated with soil production and the advantages of soilless farming, it is imperative to adopt this new technology to enhance and improve agricultural production to meet the demands of the ever-increasing human population. Therefore, this research work aims to evaluate the performance of cucumber using varied hydroponic concentrations in rice husk as the roots anchor.

The study aims to assess the efficacy of cucumber cultivation utilizing diverse hydroponic concentrations in rice husk, which serves as the roots' anchor. The specific objectives of this study were as follows:

- To ascertain the impact of differing concentrations of hydroponic solutions on the performance of cucumber
- To identify any variations in performance between the two distinct varieties of cucumber

MATERIALS AND METHODS

Description of the study area: The experimental study was carried out at the Crop, Horticulture and Landscape Experimental Farm of Ekiti State University in Ado Ekiti, situated at Latitudes 7°31 and 7°49 North of the equator and Longitudes 5°71 and 5°27 East of the Greenwich Meridian. Soilless cultivation of tomato plants was undertaken between March, 2022 and May, 2022.

Cucumber varieties: Amarisa and Darina, two cucumber varieties possessing favorable growth and yield attributes, were chosen as the test crops. Seedlings were raised in the nursery for2 weeks prior to transplantation.

Source of minerals used: The nutrient concentrate, comprising soluble NPK, Calcium Nitrate ($CaNO_3$), and Magnesium Sulfate ($MgSO_4$), was procured from a registered agro-chemicals shop and mixed in a ratio of 2:2:1, resulting in four distinct concentration levels.

Concentrations were:

- C1 (0.4 g L^{-1} of NPK, 0.4 g L^{-1} of $CaNO_3$ and 0.2 g L^{-1} of $MgSO_4$)
- C2 (0.5 g L^{-1} of NPK, 0.5 g L^{-1} of $CaNO_3$ and 0.25 g L^{-1} of $MgSO_4$)
- C3 (0.6 g L^{-1} of NPK, 0.6 g L^{-1} of $CaNO_3$ and 0.3 g L^{-1} of $MgSO_4$)
- C4 (C1, C2 and C3)

Experimental design: The experimental setup followed a Complete Randomized Design (CRD) with a total of eight treatment combinations, consisting of 2 cucumber varieties and 4 different concentrations. Each combination was replicated four times to ensure accuracy and precision in the results.

Hydroponic set-up pre-planting and post-planting operations: All materials utilized for the hydroponics system were locally sourced, the rice husk was obtained from a nearby rice milling plant. The seedlings were nurtured in a nursery for a period of 2 weeks and were subsequently transplanted into black plastic bags filled with rice husk as a growing medium.

Prior to being filled into the planting bags, the rice husks were soaked in water and sterilized with Hydrogen Peroxide (H_2O_2) and allowed to settle in a place for 2 weeks before the seedlings were planted into them.

Fertigation and trellising: The plants were irrigated twice daily with varying concentrations of the nutrient solution that had been prepared, using a watering can.

To provide support for the plant, twine was twisted around the main stem and fastened to the top pole of the screen house and the plants were trellised.

Pest and disease control: Daily monitoring and control of pests and diseases was carried out to ensure that they were managed properly.

Agronomic data collection: The following parameters were recorded:

- **Vine height:** Measured by using a measuring tape to determine the height of the plant up to the tip of the main vine
- **Number of leaves:** Direct counting of leaves on each plant
- **Leaf length:** Measured using a measuring tape
- **Leaf width (breadth):** Determined by measuring the leaf across the midrib
- **Stem girth (mm):** Measured with a Vernier caliper to determine the stem girth of the plant
- **Number of fruits per plant:** Determined by directly counting the number of harvested fruits per plant
- **Fruit length (cm):** Measured from the base to the apex of the fruit using a meter rule
- **Fruit girth (cm):** Measured at a maximum thickness in centimeters
- **Fruit weight (g):** Recorded by weighing each fruit on an electronic weighing balance (in grams)

Statistical analysis: The collected data were subjected to an analysis of variance using IBM SPSS version 20. In the case of significant differences, the means were separated by employing Duncan's Multiple Range Test at a significance level of $p = 0.05$ (DMRT).

RESULTS

Effect of nutrient concentrations and varietal difference on the number of leaves: The impact of nutrient concentration and cucumber variety on the number of leaves was displayed in Table 1. The outcomes presented demonstrated that no statistically significant difference among the four distinct nutrient concentrations employed. Nonetheless, 4 weeks after transplantation, it was observed that plants treated with concentration 3 (C3) exhibited the highest number of leaves, which were 3% higher than plants treated with concentration 1 (C1). Concerning the variety, no significant difference ($p \geq 0.05$) was observed between the varieties at week 2. However, from weeks 3 to 5 after transplantation, a significant difference ($p \leq 0.05$) was observed between the two varieties. Variety 1 (V1) exhibited a higher number of leaves than variety 2 (V2).

Effect of concentration and variety on vine height (cm) of cucumber: Table 2 illustrated the effects of nutrient concentration and varieties on the vine height of cucumbers. The findings indicated no statistically significant differences ($p \geq 0.05$) among the four concentrations used and between the two varieties. Nonetheless, at 4 weeks after transplantation, concentration 4 (C4) led to the highest vine height of 220 cm, which was 5.5, 5 and 2% greater than concentrations 1, 2 and 3, respectively.

For the varieties, at 4 weeks after transplantation, variety 1 (V1) was observed to have a higher vine height of 215.72 cm, which was 2% greater than variety 2 (V2), with a value of 211.34 cm.

Effect of concentration and variety on leaf length (cm) of cucumber: The impact of nutrient concentrations and cucumber varieties on the length of cucumber leaves.

The findings revealed no significant differences ($p \geq 0.05$) among the four distinct nutrient concentrations utilized. Nonetheless, there was a noteworthy distinction between the two varieties, with variety 2 outperforming variety 1 in terms of values at different observations as shown in Table 3.

Effect of concentration and variety on stem girth (mm) of cucumber: The influence of nutrient concentration and cucumber varieties on the stem girth of cucumber. The results demonstrated no significant difference ($p \geq 0.05$) among the four concentrations employed and also between the two varieties. However, 4 weeks after transplanting, it was observed that concentration 4 (C4) produced the largest stem girth of 7.39 cm, which was 9.45, 8.67 and 11.3% higher than concentrations 1, 2 and 3, respectively as shown in Table 4.

Table 1: Effect of concentration and variety on numbers of leaves of cucumber

	Weeks after transplanting			
Concentration	2	3	4	5
C1 (1 g L^{-1})	10.00^{a}	21.25^{a}	26.25^{a}	29.25^{a}
C2 (1.25 g L^{-1})	11.00^{a}	24.13^{a}	29^{a}	30.13^{a}
C3 (1.5 g L^{-1})	10.50^{a}	21^{a}	27.38^{a}	27.7^{a}
C4 (1, 1.25 and 1.5 g L^{-1})	10.75^{a}	22.7^{a}	26.88^{a}	27.7^{a}
p-value	0.68*	0.42*	0.74*	0.83*
Variety				
V1 (Amarisa)	11.06	24.75	30.56	33.81
V2 (Darina)	10.06	19.81	24.19	24.633
p-value	0.11*	0.00**	0.00**	0.00***

*Means non-significant, **Means significant means with the same letters in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at a 5% level of probability

Table 2: Effect of concentration and variety on vine height (cm) of cucumber

	Weeks after transplanting			
Concentration	2	3	4	5
C1 (1 g L^{-1})	30.00^{a}	88.54^{a}	145.19^{a}	208.56^{a}
C2 (1.25 g L^{-1})	37.06^{a}	90.75^{a}	158.15^{a}	209.75^{a}
C3 (1.5 g L^{-1})	34.44^{a}	93.25^{a}	166.25^{a}	215.75^{a}
C4 (1, 1.25 and 1.5 g L^{-1})	33.00^{a}	86.88^{a}	150.56^{a}	220.06^{a}
p-value	0.49*	0.83*	0.16*	0.89*
Variety				
V1 (Amarisa)	35.09	88.77	151.23	215.72
V2 (Darina)	32.47	90.94	159.03	211.34
p-value	0.39*	0.68*	0.26*	0.72**

*Means non-significant, **Means significant means with the same letters in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at a 5% level of probability

Table 3: Effect of concentration and variety on leaf length (cm) of cucumber

	Weeks after transplanting			
Concentration	2	3	4	5
C1 (1 g L^{-1})	13.81^{a}	18.48^{a}	20.23^{a}	20.87^{a}
C2 (1.25 g L^{-1})	14.38^{a}	19.69^{a}	20.8^{a}	21.03^{a}
C3 (1.5 g L^{-1})	13.23^{a}	19.69^{a}	20.38^{a}	21.10^{a}
C4 (1, 1.25 and 1.5 g L^{-1})	14.25^{a}	19.13^{a}	20.78^{a}	22.64^{a}
p-value	0.72*	0.65*	0.85*	0.69*
Varieties				
V1 (Amarisa)	12.75	18.24	19.51	20.71
V2 (Darina)	15.08	20.22	21.67	22.11
p-value	0.01**	0.02**	0.01**	0.25**

*Means non-significant, **Means significant means with the same letters in the same column are not significantly different by Duncan's Multiple Range Test (DMRT), at a 5% level of probability

Table 4: Effect of concentration and variety on stem girth(mm) of cucumber

	Weeks after transplanting			
Concentration	2	3	4	5
C1 (1 g L^{-1})	3.98^{a}	4.85^{a}	5.58^{a}	6.75^{a}
C2 (1.25 g L^{-1})	4.34^{a}	5.2^{a}	6.2^{a}	6.80^{a}
C3 (1.5 g L^{-1})	4.05^{a}	3.98^{a}	6.10^{a}	6.64^{a}
C4 (1, 1.25 and 1.5 g L^{-1})	3.56^{a}	4.47^{a}	6.20^{a}	7.39^{a}
p-value	0.52*	0.14*	0.34*	0.54*
Varieties				
V1 (Amarisa)	3.84	4.48	5.75	6.99
V2 (Darina)	4.13	4.78	6.29	6.79
p-value	0.43*	0.41*	0.06*	0.61**

*Means non-significant, **Means significant means with the same letters in the same column are not significantly different by Duncan's Multiple Range Test (DMRT), at a 5% level of probability

Table 5: Effect of nutrient concentration and variety on the yield parameter of the cucumber

	Yield parameter				
Concentration	Number of flowers	Number of fruits	Fruits length (cm)	Fruit girth (mm)	Fruit weight (g)
C1 (1 g L^{-1})	22.13^{b}	5.25^{a}	18.43^{a}	48.75^{a}	277.63^{a}
C2 (1.25 g L^{-1})	28.5^{a}	2.88^{b}	21.96^{a}	51.54^{a}	336.39^{a}
C3 (1.5g L^{-1})	24.62^{ab}	4.5^{a}	22.13^{a}	49.93^{a}	373.09^{a}
C4 (1, 1.25 and 1.5 g L^{-1})	27.13^{ab}	4.63^{a}	21.79^{a}	49.94^{a}	296.95^{a}
p-value	0.04**	0.00**	0.11*	0.97*	0.26*
Varieties					
V1 (Amarisa)	26.31	3.75	22.02	49.54	332.33
V2 (Darina)	24.88	4.88	20.13	50.54	309.69
p-value	0.38*	0.00**	0.13*	0.79*	0.53**

*Means non-significant, **Means significant means with the same letters in the same column are not significantly different by Duncan's Multiple Range Test (DMRT), at a 5% level of probability

Regarding the varieties, at 4 weeks after transplanting, variety 1 (V1) exhibited the highest stem girth, which was 2.95% greater than variety 2 (V2).

Effect of nutrient concentration and variety on the yield parameter of the cucumber: The effects of nutrient concentration and cucumber varieties on the yield parameters of cucumber. The findings suggested a significant difference among the four nutrient concentrations used in terms of the number of flowers and fruits ($p \leq 0.05$). Nevertheless, no significant difference was observed among the concentrations in relation to fruit length, girth and weight, albeit C3 displayed the highest value of 373.09 for fruit weight. Concerning varieties, no significant differences ($p \geq 0.05$) were observed in terms of the number of flowers, fruit length, girth and weight, except for the number of fruits ($p \leq 0.05$) as shown in Table 5.

DISCUSSION

Upon analyzing the outcomes of the experiment, it can be observed that the cucumber plants reacted positively to various concentrations of hydroponic nutrients, corroborating nutrient solution concentration as a critical factor in a hydroponic system[12]. This can be seen in the various growth parameters that were measured. Plants cultivated hydroponically displayed good vegetative growth[13]. Although no significant differences were observed in growth parameters across different weeks of cultivation, their values increased steadily over time. The concentration of nutrient elements like N, P and K was higher in concentration 3 than concentration 1 and 2 and this could contribute to its better performance in terms of values although, with no significant difference as observed in concentrations 1 and 2, this statement was in line with Jones[14], who related an increment in arial body of plant to increase in nitrogen. This emphasized the importance of nutrients in the well-being of plants, particularly in hydroponic cultivation, which was previously highlighted by Sublett *et al.*[15]. These researchers proposed that nutrients were essential factors that influence plant growth and biomass production in hydroponic systems.

Regarding the discrepancy in weight, where C4 had a weight of 296.95 g compared to C3 with a weight of 373.09 g, it may be due to differences in the macro and microelement concentrations present in the different nutrient solutions. As per Fageria and Baligar[16], the nutritional requirements of plants change during various developmental stages and this may account for the weight discrepancy among the different nutrient concentrations as co additionally, several reports have indicated that changes in nutrient solution concentrations affect plant growth[17].

Furthermore, the variation in weight between the two varieties, despite being cultivated under identical environmental conditions, could be linked to the unique characteristics and genetic differences between the two varieties[18].

Conclusively, the outcome of this experiment strongly advocates for the incorporation of rice husks into hydroponic systems as a growth medium and this practice should be embraced by farmers and all individuals engaged in crop production to ensure maximum yield. This approach not only helps recycle rice husks that would otherwise pose a waste management challenge but also holds immense potential in enhancing crop productivity. The proper management of nutrients represents a crucial consideration that warrants careful attention, as a poorly composed formula may impede optimal crop production. Hence, it is recommended that each person observes, tests and adjusts their nutrient composition until the ideal balance is attained for the most favorable outcome.

CONCLUSION

This study was conducted to evaluate the growth and yield parameters of cucumber using varied hydroponic nutrient solution concentrations and rice husk as a growing medium. The results indicated that soilless production of cucumber using rice husk as a growing medium can serve as a viable alternative to traditional soil cultivation. This approach could increase the production of cucumber all year round without interference from weeds. Furthermore, hydroponic cultivation could contribute to meeting the nutritional needs of humans in areas where soil for indigenous farming does not support plant growth. Based on the outcome of this experiment, it is recommended that farmers adopt the use of rice husk as a growing medium in hydroponic systems for optimal crop production.

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