Asian Journal of Agricultural and Horticultural Research

Volume 10, Issue 4, Page 95-101, 2023; Article no.AJAHR.100092
ISSN: 2581-4478

Performance of Two Varieties of Tomato *Solanum lycopersicum* L as Affected by Two Concentration of Hydroponic Solution

Kehinde-Fadare Abosede Fisayo [a*] and Adisa Rachael Ayodele [a]

[a] Department of Crop, Horticulture and Landscape Design, Ekiti State University, P.M.B. 5363, Ado-Ekiti, Ekiti State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2023/v10i4249

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/100092

Original Research Article

Received: 24/03/2023
Accepted: 30/05/2023
Published: 13/06/2023

ABSTRACT

The effects of two distinct nutrient solutions were evaluated on two tomato varieties in a hydroponic system enclosed within a screen house over the course of 12 weeks. At three weeks of age, tomato seedlings previously cultivated in a nursery were transplanted into a Kratky hydroponic system, which involves the placement of plants in a net pot, where the growing media is secured by a lid and hung above the water. All of these were held in a container containing dissolved nutrients at two solutions different in concentrations, including both major and trace elements diluted at varying levels. Growth parameters were observed and recorded over a five-week period at weekly intervals, starting from the week after transplantation. In addition, data on yield, including fruit weight, diameter, and number, were collected at harvest and documented that both concentrations (i.e. 100% and 75%) were observed to give substantial results in terms of yield. However, the 100% concentration gave a better performance in all the parameters taken.

**Corresponding author: Email: abosede.kehindefadare@eksu.edu.ng;*

Keywords: Growth parameters; hydroponics; Kratky; tomatoes.

1. INTRODUCTION

In Nigeria and numerous other African nations, the climate plays a significant role in crop production as farmers rely heavily on rainfall for their crops. Unfortunately, the environment is no longer what it used to be, and farmers are experiencing more restrictions due to the effects of climate change in their rural environment. Additionally, the low infrastructural capacity of the farmers contributes to their high reliance on rainfall for production. The consequences of a change in climate on agricultural activities are staggering. Currently, in the agrarian southwestern region of Nigeria, it is challenging to identify the beginning of the farming season due to changes in rainfall patterns and unpredictable weather [1]. These factors often cause crop failure and influence pest dynamics, resulting in severe crop diseases.

As ranchers move further south in search of open space, desert encroachment from the Sahara into the Sahel region, coupled with other climatic conditions, continue to have an impact on their way of life. This causes them to clash violently with local farmers and host communities. This has been a characteristic aspect of West Africa's economic life [2]. Farmers have been killed and evicted from their land as a result of the conflicts. There needs to be a paradigm shift toward alternate agricultural production systems in light of all these limitations.

Hydroponic crop production systems are a predictable and sustainable option for continuous production, as well as solving the problem of water availability and conflicts between farmers and herdsmen. This system suspends a plant's root in nutrient-rich water, allowing it to grow without chemicals [3]. It allows both home gardeners and commercial vegetable producers to grow plants where land is scarce or nutrient-deficient [2]. Plants grown in this system have reported achieving 20-25% higher yields than a soil-based system, with productivity 2-5 times higher [4].

Nutrient solution concentration is a critical factor in hydroponic systems as it can influence plant growth, appearance, nutritional value, shelf life and profitable production [5-7]. Extremely low nutrient concentrations can inhibit plant growth [8]. Conversely, extremely high nutrient solution concentrations cause osmotic stress, ionic toxicity, and growth restriction [8]. Several formulations of essential macro- and micronutrients have been developed to promote plant growth [9]. Nutrient solution is the only source of mineral nutrients in hydroponically grown plants, and have demonstrated that NSC influences the growth and components of spinach, tomato, cucumber, salvia, bean, artichoke, wasabi, lettuce and coriander plants [10-13]. Tomatoes are an indispensable vegetable in Nigeria, cultivated virtually by all tribes. They serve as a crucial source of vitamin C, lycopene, carotenoids with a high oxygen-radical scavenging and quenching capacity, as well as other minerals like iron and phosphorus, necessary for healthy growth [14,15]. Tomato production, like some other vegetables, faces numerous challenges, such as poor soil fertility as a result of soil quality degradation [16].

In sub-Saharan African, the soils are less fertile and have low soil organic matter content [17]. This predisposes such soils to the inability to continually support continuous cultivation due to the rapid decline in soil fertility when intensely cropped. One way to avert this challenge is to use inorganic fertilizers together with urea and single superphosphate. However, these salts could have detrimental effects on the environment.

Therefore, it is expedient to consider alternative means of cultivating healthy tomatoes instead of a method that continuously depends on soil. Therefore, this research aimed to determine tomatoes' performance in a hydroponic system using two different nutrient solution concentrations.

2. MATERIALS AND METHODS

2.1 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 $7^{o}31$ and $7^{o}49$ north of the equator and longitudes $5^{o}71$ and $5^{o}27$ east of the Greenwich Meridian. Soilless cultivation of tomato plants was undertaken between May 2021 and August 2021.

2.2 Tomato Varieties

Two tomato varieties, namely Premium F_1 and Presido F_1, were carefully selected for the study due to their superior characteristics and suitability for hydroponic cultivation. Prior to transplanting, seedlings were raised in a nursery for three weeks.

2.3 Source of Nutrient Used

The macro and micro nutrient concentrate used for the experiment was a pre-mix nutrient solution obtained from a registered agro-chemicals producer. The only variation in nutrient supply was in the mixing percentages of the solution, which were 100% concentration (normal concentration) and 75% concentration.

2.4 Experimental Design

The design of the experiment followed a Completely Randomized Design (CRD) with four treatment combinations, consisting of two varieties and two concentrations. Each treatment was comprised of three seedlings from each tomato cultivar, replicated three times, resulting in a total of 72 plants (36 per variety).

2.5 Hydroponic Preparation Pre-Planting Planting and Post-Planting Operations

The hydroponic system materials were locally sourced and prior to transplanting the seedlings, they were nurtured intensively for three weeks in nurseries. Transparent growing buckets were covered with synthetic plastic film to hinder the growth of algae. The covers of the growing buckets were perforated to accommodate the net pots in which the plants were placed.

The growing buckets served as reservoirs where nutrients were dissolved using the Kratky method. This method involves suspending plants above the container of nutrient solution and is a non-circulating technique [18]. During transplanting, great care was taken to remove the tomato plants from the soil without damaging their roots, which were kept intact exactly three weeks after planting. The soil was gently massaged out of the roots until they resembled a dirty brush, and then the roots were submerged in water to completely remove the dirt. The roots were then massaged in the water until they were clean, and they were subsequently wrapped in rockwool, which served as an anchor to hold the plant in place before it was placed in the net pot. The net pots were suspended above the growing buckets or reservoirs containing essential nutrients in solution, allowing only the root tips to touch the surface of the reservoir. As the plant grew and depleted the water level, the nutrients and water were replenished, but the container was not filled to the brim to allow oxygen circulation.

Staking was performed as a post-planting operation by firmly attaching an iron string to the upper part of the mini screen house, allowing the plants to be trained on the stake by tying the vines with a rope (4WAT). This prevented physical damage to the plants and allowed for better ventilation and proper leaf exposure to the light source. The tomato plant's concentration have the highest value for vine length with almost 12% greater than the normal concentration with presido having the lowest value. The vine length was favored at 3WAT by the normal development from transplant to fruiting stage is presented in Plates 1 to 3.

2.6 Data Collection

The response variables measured were the number of leaves, vine length, fruit number and also fruit weight.

(i) Number of leaves: Leaves per plant were collected visually and data were recorded for each plant on weekly bases from 1WAT to 5WAT *(WAT means weeks after transplanting)*
(ii) Vine length: the vine of each plant was measured from the root level to the top of the highest leaf using a meter rule and recorded in cm from 1WAT to 5WAT.
(iii) Fruit weight: each fruit weight was recorded after weighing them on an electronic weighing balance (scale) (g)

2.7 Statistical Analysis

All data were subjected to statistical analysis using SAS for mean comparison, and Duncan Multiple Range system test was used to separate the means at $P < 0.05$.

3. RESULTS

3.1 Effect of Concentration on the Vine Length of the Two Tomato Varieties

The effect of the two concentrations used on the vine length of the tomato varieties is shown in Table 1; there was no significant (P > 0.05) difference among the two varieties and also the two nutrient concentrations at 1 to 3 WAT. However at 4WAT, significant difference was observed in terms of vine length between the two concentrations used for variety 1 and also for variety 2. At 5 weeks after planting the only significance was observed with the other treatments and variety 2 grown with concentration 75% AT 5% level of probability. The normal concentration and premium at week 1 favors the plant by having the highest value for plant vine with at least 7% compared to other concentrations and variety. At 2 WAT presido with 75% concentration with presido having the lowest value. The vine length was favored at 3 WAT by the normal concentration with presido having about 20% difference from the concentration and variety with the lowest value.

However, at 4 and 5 WAT, the concentration and the variety interaction is significant (P < 0.05) on the plant vine conversion as the concentration and variety differs greatly from each other as Normal concentration with presido and Normal concentration with premium having the highest value at week 4 and 5 respectively.

3.2 Effect of Concentration and Variety on Yield Components of Tomato

Table 2 shows that the concentration and variety interaction on the number of leaves was non significant (P> 0.05) at 1 and 2 WAT but there was a slight difference in their values, concentration 75% with presido and concentration 75% with premium have the high values with a difference of about 14% and 16% respectively from the ones with the lowest value. Therefore at week 1 and 2 the concentration and variety interacted favorably to the 75% concentration with both varieties. However, significant difference (P< 0.05) was observed at week 3 to 5 with normal concentration and premium having the highest value throughout the weeks.

Table 3 shows that the concentration had no significant effect (P > 0.05) on the yield of the tomato in terms of the number of fruits although the normal concentration with presido has the highest number of fruits. However in terms of the weight of the fruits, significant difference (P < 0.05) was observed with regards to concentration as premium in normal concentration has the highest weight value with a huge difference of about 80% from presido in 75%concentration. The normal concentration therefore favors the fruit weight which may be an important factor for market purpose.

Table 1. Vine length (cm) of two varieties of tomato plants under two concentrations at 1 to 5 WAT

	Weeks after transplanting					
Varieties	**1**	**2**	**3**	**4**	**5**	
Premium	9.67a	16.57a	36.12a	45.28a	52.12a	**Normal concentration**
Presido	8.72a	16.13a	38.27a	45.85a	51.53a	
Premium	8.38a	16.18a	31.83a	38.20b	47.36a	**75% concentration**
Presido	9.00a	17.95a	28.45a	30.95c	40.98b	

Mean values in a column followed by different letters differs significantly at 5% level of probability by duncan multiple range test

Table 2. Number of leaves of two varieties of tomato plants under two concentrations at 1 to 5 WAT

	Weeks after transplanting					
Varieties	**1**	**2**	**3**	**4**	**5**	
Premium	11.77a	21.72a	57.50a	93.40a	138.33a	**Normal concentration**
Presido	10.48a	22.35a	49.92ab	77.40ab	97.67b	
Premium	11.77a	25.28a	47.18ab	69.80b	106.40b	**75% concentration**
Presido	12.00a	25.10a	41.18b	48.83c	68.00c	

Mean values in a column followed by different letters differs significantly at 5% level of probability by duncan multiple range test

Table 3. Yield components of two varieties of tomato plants under two concentrations at 1 to 5 WAT

Varieties	Number of fruits	Weight of fruits	
Premium	6.17 a	176.33 a	**Normal Concentration**
Presido	5.50 a	96.00 a	
Premium	8.17 a	69.83 ab	**75% Concentration**
Presido	8.00 a	60.20 ab	

Mean values in a column followed by different letters differs significantly at 5% level of probability by duncan multiple range test

Plate 1. Tomato plant at transplanting

Plate 2. Developmental stage

Plate 3. Fruiting stage

4. DISCUSSION

In hydroponics culture, fertilizers are introduced into the nutrient solution as ions, and numerous formulations have been devised to optimize nutrient uptake and augment plant growth.

The current investigation exemplifies that the concentration of the nutrient solution exerts an influence on the growth and constituents of tomato plants, as substantiated by prior research, including studies conducted by Savvas and Adamidis, [8] and Oztekin et al. [10]. Furthermore, our own inquiry indicates that a reduction in the concentration of the nutrient solution gives rise to a corresponding diminution in nutrient availability. Specifically, we observed that the levels of normal concentration surpassed those of the reduced concentration level of 75%, which is in concurrence with Petropoulos et al. [19], who reported that augmenting nitrogen levels from 150-200 mg/L could amplify the number of leaves produced in greenhouse lettuce.

The enhancement of the yield of tomatoes cultivated with a normal concentration, compared to that of 75%, can also be attributed to the fact that the nutrient level of the 75% concentration has declined below what the plant necessitates, corroborating the findings of Fallovo et al. [20], who remarked that excessively low levels generally result in nutrient deficiencies. In conclusion, this experiment attests to the indispensable role of a balanced nutrient composition in achieving optimal plant yields.

5. CONCLUSIONS

This study highlights the efficacy of hydroponics in tomato production, offering an easier and disease-free approach to increasing yields. Additionally, the provision of adequate nutrients is crucial for optimal tomato performance, particularly with regards to fruit yield and size. Interestingly, our findings indicate that the interaction of concentration and variety on tomato yield is negligible, as both varieties perform well under both concentrations, with only a slight variance in yield.

6. RECOMMENDATIONS

Based on the result of this experiment, it is recommended that hydroponics should be adopted by farmers for optimum crop production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Audu EB, Audu HO, Binbol NL, Gana JN. Climate change and its implication on agriculture in Nigeria. Abuja J. Geograp. Develop. 2013;3(2):1–15.
2. Tonah S. Managing farmer-herder conflicts in Ghana’s Volta Basin. Ibadana Journal of Social Sciences. 2006;4(1):33-45
3. Dehnavard S, Souri MK, Mardanlu. Tomato growth responses to foliar application of ammonium sulfate in hydroponic culture. Journal of Plant Nutrition. 2017;40(3):315-323.
4. United Nations; 2017.
5. Pourranjbari Saghaiesh S, Souri MK, Moghaddam M. Characterization of nutrients uptake and enzymes activity in khatouni melon (*Cucumis melo* var. inodorus) seedlings under different concentrations of nitrogen, potassium and phosphorus of nutrient solution. Journal of Plant Nutrition. 2019;42(2):178-185.
6. Souri MK, Hatamian M. Aminochelates in plant nutrition: A review. J of Plant Nutrition. 2019;42(1):67-78.
7. Pourranjbari Saghaiesh S, Souri MK. Root growth characteristics of khatouni melon seedlings as affected by potassium nutrition. Hortorum Cultus. 2018;17(5):191-198.
8. Savvas D, Adamidis K. Automated management of nutrient solutions based on target electrical conductivity, pH, and nutrient concentration ratios. J. Plant Nutr. 1999;22:1415–1432.
9. Jones JB, Jr. Hydroponics: Its history and use in plant nutrition studies. J. Plant Nutr. 1982;5:1003–1030.
10. Oztekin GB, Uluda˘g T, Tüzel Y. Growing spinach (*Spinacia oleracea* L.) in a floating system with different concentrations of nutrient solution. Appl. Ecol. Environ. 2018;16:3333–3350.
11. Hoang NN, Kitaya Y, Shibuya T, Endo R. Development of an *in vitro* hydroponic culture system for wasabi nursery plant production—Effects of nutrient concentration and supporting material on plantlet growth. Sci. Hortic. 2019;245:237–243.
12. Mohammadipour N, Souri MK. Effects of different levels of glycine in the nutrient solution on the growth, nutrient composition and antioxidant activity of coriander (*Coriandrum sativum* L.). Acta Agrobotanica. 2019;72(1).
13. Mohammadipour N, Souri MK. Beneficial effects of glycine on growth and leaf nutrient concentrations of coriander (*Coriandrum sativum*) plants. Journal of Plant Nutrition. 2019;42(14):1637-1644.
14. Dumas Y, Dadomo M, Lucca GD, Grolier P. Effect of environmental factors and agricultural technologies on antioxidant content of tomatoes. Journal of the science of Food and Agriculture. 2003;83:369-383.
Available:https://doi.org/10.10 02/jsfa.1370
15. Babalola DA, Iroh YO, Omonona BT, Oyekanmi MO. Determinant of postharvest losses in tomato production: A case study of Imeko-Afon local government area of Ogun state. Acta SATECH. 2010;3: 14-18.
16. Liang LZ, Zhao XQ, Yi XY, Chen ZC, Dong XY, Chen RF, Shen RF. Excessive application of nitrogen and phosphorus fertilizers induces soil acidification and phosphorus enrichment during vegetable production in Yangtze River Delta, China. Soil Use Manag. 2013;29:161–168.
17. Shiyam JO, Binang WB, Effect of poultry manure and plant population on productivity of fluted pumpkin (*Telfaiaria*

occidentalis Hook F.) in Calabar, Nigeria. Journal of Organic Systems. 2013;8:29-35.

18. Arun Maurya, et al. "Study of hydroponic systems and their variations". International Journal of Agricultural Science and Research. 2017;7(5):547.
19. Petropoulos SA, Chatzieustratiou E, Constantopoulou E, Kapotis G. Yield and quality of lettuce and rocket grown in floating culture system. Not. Bot. Horti Agrobot. Cluj-Napoca. 2016;44:603–612.
20. Fallovo C, Rouphael Y, Rea E, Battistelli A, Colla G. Nutrient solution of food and Agriculture. 2009;89(10):1682-1689.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/100092