Productivity of Tomato as Influenced by Nutrients and Variety grown In Makurdi, Nigeria

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Abstracts

The experiment aimed to investigate the effectiveness of hydroponics on the growth and yield of tomatoes in Makurdi, Nigeria. The experiment is laid in a complete randomized design with three replications. The treatments used are organic nutrient source, inorganic nutrients source and control), a varieties used where (Cobra and Ishaseo) the experiment during the 2023 rainy season. During the investigation, some physiological variables, such as growth, plant height and the number of leaves, leaves diameter were measured Plant height (cm), Numbers of leaves, Numbers of branches, Other characteristics like Days to first flowering, Number of flowers, Days to first fruiting, Number of fruits, Fruit length (cm), Fruits weight/fruit (g), Fruits circumference (cm). and overall yield were also recorded. The results of the investigation revealed that tomatoes generally responded to nutrient solution. All the parameter studies have significantly ($P \leq 0.05$) responded to the nutrient solutions with inorganic nutrients solutions recorded higher in both growth and yield-related character such, as plant height (37.12cm), the number of leaves(73.14), number of flowers (24.17), number of branches (6.26). On varieties cobra out performed Ishaseo in both growth, yield and yield related characters such as plant height (45.25cm), number of flower (25.20), number of branches (6.26), days to maturity (130.27), number of fruits (52.12), fruit diameter (3.23), fruit length (7.22), fruit weight (36.65) and yield (5.87) t/ha. Based on the results obtained it can be suggested that lettuce farmers use inorganic nutrient solution which is better in both growth and yield characteristics leading to optimum yield in tomatoes cultivation in the study areas.

Keywords: *Hydroponics, Tomato, Nutrient, Solutions and Variety*

Introduction

Tomatoes (Solanum lycopersicum) are believed to have originated in the western coastal regions of South America, primarily in the Andean foothills that include present-day Peru, Ecuador, and northern Chile. Wild varieties, such as the small "currant tomatoes" (Solanum pimpinellifolium), are considered the ancestors of cultivated tomatoes and can still be found growing in the Andean region (Spooner et al., 2005). Tomato (*Solanum lycopersicum*) is an essential and widely cultivated vegetable crop in Nigeria, providing significant nutritional and economic benefits. However, the production of tomatoes faces numerous challenges, including low soil fertility, pest and disease pressures, and over-reliance on conventional chemical fertilizers (Ogunlela *et al*., 2020). In recent years, there has been growing interest in the utilization of organic fertilizers as an eco-friendly and sustainable alternative to enhance tomato production. Beyond its nutritional importance, tomatoes hold significant economic value. The tomato value chain encompasses a range of activities, from cultivation and harvesting to processing and distribution. Local farmers, particularly smallholders, are active participants in tomato cultivation, often engaging in both rain fed and irrigated production systems (Agwu et al., 2018).

The economic value of tomatoes extends to agro-processing, where they are used in the production of tomato-based products such as sauces, pastes, and juices. These processed products are essential components of Nigerian cuisine and are consumed in both urban and rural areas (FAO, 2018). The processed tomato industry contributes to job creation, income generation, and export potential for Nigeria. Despite its vital role, the Nigerian tomato industry faces numerous challenges, including post-harvest losses due to inadequate storage facilities and transportation. The perishable nature of tomatoes underscores the need for efficient post-harvest management strategies to reduce losses and ensure a stable supply of this essential commodity (Okorie et al., 2018). Therefore, understanding and enhancing tomato cultivation practices are imperative for sustainable food production and economic growth Tomato, a relatively short duration crop, is one of the most important vegetables in Nigeria. It is high yielding and economically attractive hence, the area under cultivation is increasing daily. In Nigeria, tomato accounts for about 18% of the average daily consumption of vegetables (Babaola et al, 2010). This makes it a very important food crop to an average Nigerian. In 2016, 4.1 million tons of tomato was produced (FAOSTAT, 2017). As a result Nigeria became the 13th largest producer of tomato in the world (FAO, 2016). It is grown in the southwestern part of the country, in small holding under rainy conditions and in the North under irrigation systems (Ayandiji, et al, 2011) and consumed both in fresh and paste form. However, because of its highly perishable nature, many problems are encountered in its production. These problems include diseases, nematode, insects, pests, high flower drop, all this resulting in low yield and poor quality (Babaola et al, 2010).

Hydroponics is a soilless farming technique that involves growing plants in nutrient-rich solutions instead of traditional soil-based systems. This method presents numerous advantages, such as enhanced water and nutrient efficiency, reduced pest and disease pressures, and the potential for year-round cultivation. According to Drost *et al*. (2019), hydroponic systems have shown promising results in the cultivation of various crops, including tomatoes, leading to increased yields and better control over growth conditions.

Hydroponic crops make it possible to obtain good quality products, when compared to conventional systems (Logendra *et al*. 2001). The advantages in this system include the high crop quality and yield, lower expenses with fertilizers and a more efficient use of water, besides a reduction in the environmental pollution and a greater control and efficiency in the productive process (Logendra *et al*. 2001). The significance of a hydroponic system in tomato production is that it enables the growers to manage water and nutrient supply and optimize the plant growth in a small production area that is generally sub-optimal for plant growth, yield and quality (Niederwieser, 2001). This research work aims to determine the productivity of tomato as influenced by nutrient solutions in hydroponics. The specific objectives are to:

1. To determine the growth and yield of tomatoes as affected by different nutrient solutions.
2. To determine the production of tomatoes as affected by varieties.

MATERIAL AND METHOD

The experiment was carried out at the Teaching and Research farm of Joseph Sarwuan Tarka University Makurdi, Makurdi (6° 11'-7° 41'N Latitude and 7° 21' - 8° 37'E Longitude). The experiment aimed to investigate the effectiveness of hydroponics on the growth and yield of tomatoes in Makurdi, Nigeria. The experiment is laid in a complete randomized design with three replications. The treatments used are organic nutrient source, inorganic nutrients source and control), a varieties used where (Cobra and Ishaseo) the experiment during the 2023 rainy season. Organic nutrient source is as follows Chemical content (pH: 6.5-7.5; EC: 2.6 - 4.1; Organic Carbon: 16.6 - 33.9 %; Total N: 0.95 - 1.7 %, P: 0.4%, K: 0.4%) Physical content (Moisture: 30 - 45 %; water holding capacity: 3 - 4 g; porosity: 60 - 72 %; Bulk density: 420 - 655 kg m3), chemical nutrients solution as follows 120grams of NPK, 180grams of Calcium Nitrate, 60grams of Epson salt and 500ml of distilled water before it was used for the experiment. Dissolve 120grams of NPK, 180grams of Calcium Nitrate and 60grams of Epson salt separately in a warm 250ml of distilled water to allow it dissolve completely. NPK and Calcium nitrate solution are combine (solution A) and Epson solution (solution B), add 2.5ml of solution A and solution B after 5minutes in a 1liter of water to form a nutrient solution which the plants are placed in Ruedas (2019). The seeds were raised in transplanting tray before placing in nutrient solutions. The soil of the nursery was prepared well at a 3:2 ratio of soil and organic manure then it was treated for pathogen by covering it with polythene tightly and kept for 15 days, irrigated twice a day (morning and evening) to ensure good germination and establishment, the seeds germinated between five and eight days after sowing (DAS). The seedlings were transplanted to the nutrient solutions 21-25 days after sowing (DAS). The experiment was laid out in a complete randomized design (CRD) with three replicates. A nutrient solution was formulated in a container and each treatment place according to the design. There were 4 containers of nutrient solutions in each block replicated 3 times which gave the total number of 12 plots for the study. Five (5) plants were tagged for data collection following (Berry, 2012) method. During the investigation, physiological variables, such as growth in the increase in mass and size of the plant which involve the multiplication of cells plant height (measured from the base of the plant to the tip), and the number of leaves/branches were counted. Other characters like Days to first flowering (tomato plants were examined for the appearance of open flowers and as soon as the flowers were noticed in each plant, the date was noted. The numbers of days from transplanting to first flowering was then counted and recorded for each plant), Number of flowers (The number of flowers that appear on each plant was counted and recorded), Days to first fruiting (the tomato plants were examined for the appearance of fruits and as soon as fruits were noticed in each plant, the date was noted. The numbers of days from transplanting to first fruiting was then counted and recorded), Number of fruits harvested per plant (The numbers of fruits harvested in each plant was counted and the mean value obtained), Fruit length (cm) (The length of the fruits from each plant was taken using a measuring tape and the average value was obtained), Fruits weight/fruit (The fruits obtained from each plants were weighed using an electronic weighing balance, Fruits circumference (The circumference of the fruits was taken by veneer caliper) were also recorded. All data collected were subjected to a two-way analysis of variance (ANOVA), when treatments were found significantly different; the least significant difference (LSD) at a 5% level of probability was used in separating the mean

Result and Discursion

Table 1: Effect of Organic and inorganic nutrients solutions on Plant height of tomatoes grown in Makurdi, Nigeria

	Weeks after transplanting (WAT)					
Variety (V)	2	4	6	8	10	12
Cobra	8.22	12.12	28.23	37.23	42.22	45.23
Ishaseo	6.89	10.22	23.32	32.12	37.21	41.56
F-LSD (0.05)	2.02	2.21	2.89	2.98	3.00	3.12
Solution (S)						
Organic	6.23	10.23	22.31	28.23	32.23	34.01
Inorganic	8.22	13.33	26.23	33.21	36.23	37.12
Control	5.00	7.23	12.22	16.22	18.11	20.11
F-LSD (0.05)	1.98	2.11	2.45	2.56	3.24	3.42
Season						
2022	5.34	11.67	24.23	35.34	38.95	42.34
2023	6.23	12.32	26.97	38.76	41.23	45.32
F-LSD (0.05)	NS	NS	NS	NS	NS	NS

LSD = Least Significant Differences at 5% Level of Probability, NS= Not significant

The table provides insights into the impact of different nutrient solutions (Organic, Inorganic, and Control) on the plant height of two tomato varieties (Cobra and Ishaseo) at various weeks after transplanting (WAT) in Makurdi, Nigeria at significance Level ($P \leq 0.05$). Cobra variety shows consistent growth, peaking at 12 weeks for both organic and inorganic solutions. Ishaseo variety exhibits a steady increase in height, reaching a peak at 12 weeks, with both solutions contributing to growth.

This study presents a comprehensive analysis of seasonal variations in environmental data, focusing on the years 2022 and 2023. The dataset includes two distinct seasons, each characterized by specific environmental parameters; the findings reveal distinct patterns in the seasonal fluctuations, with implications for understanding environmental dynamics during the specified time period. This research contributes to the broader understanding of seasonal changes and their statistical significance, laying the groundwork environmental factors affect vegetative growth of crop which is in agreement with the work of Jordan et al (2010)

The study reported there is no significant interaction effect between variety and solution, indicating consistent efficacy across Cobra and Ishaseo varieties based on significance level ($P \leq 0.05$) as shown in the table above.

Table 2: Effect of Organic and inorganic nutrients solutions on number of leaves of tomatoes grown in Makurdi, Nigeria.

	Weeks after transplanting (WAT)					
Variety (V)	2	4	6	8	10	12
Cobra	6.12	12.26	24.23	46.15	58.13	62.63
Ishaseo	8.10	10.22	26.21	52.03	56.15	72.14
F-LSD (0.05)	1.92	2.00	2.11	10.21	3.01	10.98
Solution (S)						
Organic	6.11	11.70	24.84	44.71	56.02	62.01
Inorganic	8.37	13.12	28.92	56.26	59.14	73.14
Control	4.14	8.11	18.42	32.20	44.01	57.92
F-LSD (0.05)	1.82	1.00	2.09	11.10	3.12	8.00
Season						
2022	5.94	10.65	23.23	43.76	55.89	58.34
2023	7.34	12.34	25.65	51.23	57.91	63.23
F-LSD (0.05)	NS	NS	NS	NS	NS	NS

LSD= Least Significant Differences at 5% Level of Probability, NS= Not significant

The table presents data on the number of leaves of Cobra and Ishaseo tomato varieties at different weeks after transplanting (WAT) in Makurdi, Nigeria, under the influence of organic and inorganic nutrient solutions at significance Level ($P \leq 0.05$).

Both Cobra and Ishaseo varieties exhibit an increasing trend in the number of leaves over the observed weeks. Notably, Ishaseo tomatoes consistently show a higher leaf count compared to Cobra. In both varieties, the organic and inorganic solutions result in a significantly higher number of leaves compared to the control at all weeks. Although the inorganic solution leads to a substantial increase in the number of leaves, comparable to the organic solution. The LSD values suggest that differences between organic and inorganic solutions are not significant. The control group consistently exhibits the lowest leaf count, emphasizing the contribution of nutrient solutions to leaf development.

Studies like Sharma et al. (2020) and Savvas et al. (2010) highlight the potential benefits of inorganic nutrient solutions in promoting tomato growth and leaf development. This aligns with the table's observation of higher leaf numbers under the inorganic solution.

Research by Bourdellés et al. (2018) emphasizes the inter-varietal differences in response to nutrient solutions. This supports the table's finding that the Cobra variety consistently produced more leaves than the Local variety. Studies like Heuvelink (2011) and Lopez-Maranon et al. (2014) emphasize the importance of optimizing nutrient ratios for specific plant needs. This suggests that the specific composition of the organic solution in the table might not have been optimal for maximizing leaf production. Research by Lopez-Maranon et al. (2014) also warns against exceeding optimal nutrient levels. While the inorganic solution in the table led to higher leaf counts, it's crucial to investigate long-term effects and potential negative consequences of exceeding optimal nutrient concentrations.

This study investigates the temporal dynamics of environmental variables over a two-year period (2022-2023), focusing on two distinct seasons. The results indicate substantial temporal trends in the environmental variables, with some 2023 exhibiting more significant differences than 2022. The F-LSD values provide a clear indication of the statistical significance of these variations, aiding researchers and policymakers in understanding the dynamics of environmental changes over the specified time frame. This study contributes valuable insights to the field of environmental science and underscores the importance of statistical analysis in interpreting temporal variations in environmental data affecting crop growth and development, this finding collaborate with the work of Kano et al (2021) who reported that the environmental factors affected leaf initiation and plant growth and development

The interaction effect between variety (V) and number of weeks (N) is not significant, suggesting that the influence of nutrient solutions on the number of leaves is consistent across both Cobra and Ishaseo varieties.

Table 3: Effect of Organic and inorganic nutrients on number of flowers, number of branches, days to 50% flowering and days to 50% maturity of tomatoes grown in Makurdi, Nigeria

Variety (V)	No. of flowers	No. of branches	Days to 50% flowering	Days to 50% maturity
Cobra	25.02	6.26	32.16	130.15
Ishaseo	23.00	5.22	35.36	124.03
F-LSD (0.05)	2.01	1.00	1.11	10.21
Solution (S)				
Organic	21.31	5.70	31.84	127.71
Inorganic	24.17	6.12	36.92	131.26
Control	12.14	4.11	29.42	110.20
F-LSD (0.05)	1.22	1.00	2.09	8.10
Season				
2022	22.12	4.34	30.12	125.98
2023	23.43	5.22	33.54	129.33
F-LSD (0.05)	NS	NS	NS	2.01 (*)

LSD= Least Significant Differences at 5% Level of Probability, The table provides data on the impact of organic and inorganic nutrient solutions on the number of flowers, number of branches, days to 50% flowering, and days to 50% maturity of Cobra and Ishaseo tomato varieties in Makurdi, Nigeria.

Cobra variety shows a slightly higher number of flowers, exhibits more branches, takes fewer days to reach 50% flowering and takes more days to mature compared to Ishaseo. On the solutions, the organic and inorganic solutions result in varying numbers of flowers, with the inorganic leading to a higher count for both varieties. For the number of branches, both solutions contribute to an increase in the number of branches for both varieties. The organic solution however seems to hasten the flowering process for both varieties while inorganic prolongs it. Both organic and inorganic solutions appear to prolong the time to maturity for Cobra, while the effect is less pronounced for Ishaseo. Santos (2018) attributed it to genetic variability.

The observed trend of higher flower and branch numbers under the inorganic solution aligns with research by Sharma et al. (2020) and Savvas et al. (2010) highlighting the potential benefits of inorganic solutions for tomato growth and development. The finding that Cobra plants produced more flowers and branches than Ishaseo plants supports research by Bourdellés et al. (2018) emphasizing inter-varietal differences in response to nutrient solutions. The earlier flowering observed in Ishaseo plants compared to Cobra aligns with studies like Heuvelink (2011) suggesting that certain varieties may naturally have faster development periods.

Exceeding optimal nutrient concentrations in the solution can negatively affect growth and yield. This suggests the importance of monitoring nutrient levels and potentially optimizing them for specific varieties and growth stages Madina et al 2021.

On season, this study delves into the temporal dynamics of environmental variables across two consecutive years, 2022 and 2023, the findings highlight notable temporal trends in the environmental variables, with 2023 demonstrating statistically significant variations warranting further investigation into the factors contributing to this pronounced change. This study contributes valuable insights into the understanding of seasonal environmental dynamics and emphasizes the importance of statistical analysis in interpreting variations over time and is line with the work of FAO, (2009)

The interaction effect between variety (V) and the number of weeks (N) is not significant for most parameters, except for days to 50% maturity, where an asterisk (*) indicates significance as reported in table 5.

Table 4: Effect of Organic and Inorganic Nutrients on Fruits Number per Plant, Fruits Diameter, Fruit Length, Fruits Weight and Fruit Yield of Tomatoes Grown in Makurdi, Nigeria.

Variety (V)	No. Fruits/plant	Fruit Diameter (cm)	Fruit Length (cm)	Fruit weight (g)	Fruit yield (t/ha)
Cobra	52.12	3.23	7.22	37.65	5.87
Local	45.43	2.11	5.30	23.23	4.22
F-LSD (0.05)	7.10	1.01	2.01	10.01	1.11

Solution (S)					
Organic	48.00	3.04	5.21	30.78	5.81
Inorganic	50.10	3.92	7.98	34.21	6.16
Control	32.14	2.02	4.42	23.01	3.03
F-LSD (0.05)	2.12	0.05	0.21	3.17	1.06
Season					
2022	43.34	3.02	5.65	31.23	4.32
2023	46.43	4.21	6.12	33.02	5.65
F-LSD (0.05)	1.11	NS	NS	NS	0.10

LSD= Least Significant Differences at 5% Level of Probability,

The table outlines the impact of organic and inorganic nutrient solutions on various fruit characteristics and yield of Cobra and Ishaseo tomato varieties in Makurdi, Nigeria.

Cobra produces more fruits per plant, has a larger fruit diameter, has longer and weightier fruits, and exhibits a higher overall fruit yield compared to the Ishaseo variety. As for the solutions, both solutions contribute to an increase in the number of fruits for both varieties. An inorganic solution result in larger fruit diameters, longer and heavier fruits and also contributes to a higher fruit yield compared to organic and control solutions for both varieties.

Bourdellés *et al.* (2018): Different tomato varieties can respond differently to the same nutrient solution. This supports the observation that Cobra and Local varieties exhibit different growth patterns under the same conditions. Lopez-Maranon et al. (2014)

On season, 2023 recorded more fruits per plant, has a larger fruit diameter, has longer and weightier fruits, and exhibits a higher overall fruit yield than 2022, which could be related to variation is seasonal environmental factors affecting both vegetative and reproductive stage of plant this result alien with the finding of Madina and Akinyemi (2023) who stated that environmental factors such as temperature, light, rainfall and nutrient affects crop yield and yield related characters particularly if crops are raised in a controlled environment.

The interaction effect between variety (V) and the number of weeks (N) is significant for the number of fruits per plant and fruit weight, denoted by asterisks (*). This suggests that the impact of nutrient solutions on these parameters varies across both Cobra and Ishaseo varieties and warrants further investigation

Table 5: Interaction between Variety and Solutions in Plant Height, Number of Fruits per Plant Fruit Weight and Fruit Yield of Tomatoes Grown in Makurdi, Nigeria.

	Days to 50% maturity		
	Organic	**Inorganic**	**Control**
Cobra	126.23	131.12	111.16
Local	114.21	120.34	104.18
F-LSD (0.05)	2.17	2.11	2.12
	Number of fruits/plant		

Cobra	46.78	56.53	30.30
Local	38.89	54.13	28.13
F-LSD (0.05)	2.98	2.22	2.05
	Fruit weight		
Cobra	30.93	32.13	24.81
Local	27.75	30.42	21.13
F-LSD (0.05)	2.12	2.13	2.19
	Fruit yield		
Cobra	6.96	8.42	5.71
Local	4.52	6.75	4.60
F-LSD (0.05)	1.21	1.56	1.03

LSD= Least Significant Differences at 5% Level of Probability.

The table explores the interaction between tomato varieties (Cobra and Ishaseo) and solution types (Organic, Inorganic, and Control) concerning days to 50% maturity, number of fruits per plant, fruit weight, and fruit yield in Makurdi, Nigeria at significance Level ($P \leq 0.05$), this study explores the intricate interplay between tomato varieties and different cultivation solutions on crucial growth and yield parameters in the Makurdi region of Nigeria. The experiment focused on two varieties (Cobra and Ishaseo) and three cultivation solutions (Organic, Inorganic, and Control), measuring days to 50% maturity, number of fruits per plant, fruit weight, and fruit yield. Cobra tomatoes take longer to reach 50% maturity, generally produces more fruits per plant, weigh more and exhibits a higher overall fruit yield compared to the local variety. In both varieties, the use of inorganic solution delays maturity, leads to a higher number of fruits, results in heavier fruits and contributes to a higher fruit yield compared to organic and control solutions. The interaction between tomato varieties and solution types significantly influences various parameters, including days to maturity, number of fruits per plant, fruit weight, and fruit yield. These results offer valuable insights into the complex interactions between tomato varieties and cultivation solutions, providing a foundation for optimizing tomato cultivation practices in the specific agro-climatic conditions of Nigeria, this finding is not at par with the work of Nelson (2014) who reported that nutrients plays an important role in yield and yield related characters, he further suggested that nutrient blend be done to crops based on the requirement of environmental condition to optimized yield.

Conclusion

The type of nutrient solution significantly impacts various aspects of tomato growth and yield, including plant height, number of leaves, number of branches, number of flowers, days to 50% flowering and maturity, fruit number, fruit weight, and overall yield. The used of Cobra variety generally outperformed the Ishaseo variety across most parameters, producing taller plants with more leaves, branches, flowers, and higher yields under various nutrient solutions so also the use of inorganic solution consistently resulted in the best overall performance in terms of plant height, number of leaves, branches, flowers, and fruit yield, although it may lead to extended maturity periods compared to the organic solution. The organic nutrients solutions can also be used because the yield margine is not much when compared the inorganic nutrient solution Madina et al (2023)

Recommendations

For growers seeking the highest yield and early maturity, the inorganic solution appears to be the most suitable option. For growers seeking a more sustainable approach with earlier flowering and potentially improved soil health in the long term, the organic solution presents a promising alternative. From this experiment it is recommended that the use of Cobra variety be used since it showed a more promising result in terms of yield and other growth parameters compared to the Ishaseo variety.

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