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GROWTH AND YIELD OF TOMATO (*Solanum lycopersicum*) CULTIVARS AS AFFECTED BY HYDROPONIC NUTRIENT SOLUTIONS

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ABSTRACT
A study was carried out at the Kwara State University Teaching and Research Farm, between February and June 2024 to investigate the growth and fruit yield of tomato cultivars (Diva F1 and Rio grande) under different hydroponic solutions (Bic liquid and Bic granule). The experiment was laid out in a completely randomized design and replicated three times. The pH of the nutrient solution during the study ranges between 6.4 -6.7 while the EC ranges between 2.10 dSm^{-1} – 3.02 dSm^{-1}.Except at 2WAT, the hydroponic solution in a liquid form significantly had fewer leaves than the granular nutrient solution in the Diva F1 tomato cultivar. The tomato cultivar under the granular solution took more days to attain flowering and fruiting than the liquid solution. Similarly, Diva F1 significantly attained flowering and fruiting earlier than the Rio Grande. Under the two nutrient solutions, the highest fruit yield in the Diva F1 was obtained in the granular nutrient solution whereas the higher fruit yield from the Rio grande cultivar was recorded in a liquid nutrient solution. In general, highest fruit yield was obtained from the Rio grande under granular nutrient solution. Rio grande under granular Bic solution is therefore recommended for growers in hydroponic system.

Keywords: Diva F1, fruit yield, nutrient solution, Rio grande

INTRODUCTION

Hydroponics is an engineering method of growing plants that uses a nutrient solution and soilless growing media to give the precise nutrients needed for plant growth and development (Sarvas, 2003). The practice has become increasingly popular in comparison to conventional cultivation because of increased yield per unit area, water use efficiency, fertilizer management, all-year production, and decreased incidence of pests and diseases (Sharma *et al*., 2018; Spray and Spray, 2019; Kaushal *et al*., 2022). The interactions between the nutrients in the nutrient solution can have a beneficial or negative impact on crop development, depending on the stages, amounts, combinations, and balance of crop growth (Sheng-Xiu *et al.*, 2009). According to Mayavan *et al.* (2017), plants require a variety of pH values to guarantee that all nutrients are available for uptake. However, the optimal pH for maximal growth vary not only between species, but also between cultivars, climatic circumstances, and soil, substrate, or nutrient solution conditions Islam.

In hydroponic production systems, one of the most essential and manageable cultural practices is EC management, which influences the visual, nutritional, and phytochemical quality of leafy vegetables (Yang *et al.*, 2021). Each plant species has a specific rate of nutrient solution uptake; overly high or low nutrient solution levels have a deleterious effect on plants. Mineral concentrations that are too high or too low, or an unbalanced ion composition in the nutrient solution, might impede plant growth and cause toxicity or deficiencies in certain nutrients (Chrysargyris *et al.*, 2021). Many hydroponic nutrient solutions are available in hydroponic farming, but the optimum dosage is crucial for selecting a specific crop. Among these hydroponic solutions, BIC in granular and BIC in liquid forms are outstanding. Although studies on the tomato crop have shown that the hydroponic system increases production and improves the efficiency of using water and fertilizers (Rosa-Rodríguez *et al*., 2020) comparative assessment of tomato cultivars to these common hydroponic solutions is absent.

Globally, tomatoes are grown in temperate, subtropical, and tropical climates (Blanca *et al.,* 2012) and are one of the most widely grown vegetables in Nigeria. Nigeria ranks as one of the world's largest tomato growers, ranking second after Egypt in Africa, with a total production of 3, 684,566.7 metric tons in 2022 (World Data Atlas, 2023). Many tomato cultivars are cultivated in Nigeria, these cultivars however, have different characteristics, including sensitivity to temperature extremes, tolerance or susceptibility to insects and diseases, fruit quality and size as well as yield. To obtain optimum yield, the optimal growing

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conditions for specific cultivars need to be determined, because the choice of the wrong cultivar could lead to large financial losses. Although considerable information is available on hydroponic tomato production, there is limited information on cultivar response to the available nutrient solutions. This research was therefore carried out to assess the response of tomato cultivars to different hydroponic solutions to determine the appropriate tomato cultivar and suitable hydroponic solution for tomatoes in hydroponic cultivation.

MATERIALS AND METHODS

Study area

The experiment was conducted at the Kwara State University Teaching and Research Farm, Faculty of Agriculture screen house between February and July 2024. The study location is approximately 316.37 meters above sea level, with latitude 08°43'N and longitude 4°28'E. Malete is located in the Southern Guinea Savannah agroecological zone of Nigeria, characterized by distinct wet and dry seasons. The wet season commences in March or April and ends in October, with a dry spell from mid-July to mid-August.

Treatments and Experimental Design

The study was carried out at the screen house of the Department of Crop Production, Faculty of Agriculture, Kwara State University, Malete. The experiment comprised of factorial combination of two nutrient solutions (BIC liquid and BIC granules) and two cultivars of tomato (Diva and Rio grande). These were laid in a completely randomized design and replicated three times.

Construction of a hydroponic system

A 16 mm Iron was welded at a distance of 1.2 meters with 1.4 meters high at an angle of 60^{o} upon which the 12 PVC pipes were attached. The PVC pipes for the distribution of nutrient solution were perorated with a 12 mm electrical machine at a distance of 60 cm. The 4" cover plate with PVC gum was inserted at the end of each PV pipe to prevent water wastage. The pipes were connected with a 1/2 "Pipe to supply nutrient solutions from the tank to a 4" pipe. A 1/2" elbow was also connected to the pipes for easy flow of nutrient solutions as well as for easy draining of water when necessary. Ball gauges were attached to each pipe to regulate the flow of nutrient solution from the tank to the PVC pipe. The tank containing the hydroponic solutions was mounted on a wooden tripod stand of 6.0 m (Plate 1).

Preparation of the Solution, Nursery Establishment, and Transplanting

The hydroponic nutrient solution granules were prepared as directed by the manufacturer by dissolving 20g and 10 ml respectively plus solution A and solution B into 20 liters of water to form a full dose (info@bicfarmsconcepts.com). The seeds were raised in a seed tray using potting soil for three weeks before transplanting into the hydroponic solutions. At the nursery, the seeds were watered gently before and after germination until they were transplanted. The seedlings were transplanted with naked roots by carefully removing the soil and inserting the seedlings into the slightly opened foam which was used to anchor the plant, such that the roots were in contact with the solution.

Data Collection and Analysis

Data were collected on pH, electrical conductivity, temperature, numbers of leaves and leaf area at 2, 4, 6, and 8 WAT, stem girth at 4 and 6 WAT, days to 50 % flowering and fruiting, and fruit yield. These were subjected to analysis of variance using DSAASTAT ver.1.101. (2011). Significant treatment means were separated using least significant difference at 5 % level of probability.

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Plate 1: A unit set of hydroponic system

RESULTS

The pH of the nutrient solution ranges between 6.4 and 6.7 while the EC ranges between 2.10 dSm^{-1} – 3.02 dSm^{-1}.The highest temperature, 41.00C, was recorded the second week after transplanting (Table 1). The significant interaction between the nutrient solutions and several leaves of tomato cultivars is presented in Figure 1. Except at 2 week after transplanting (WAT), the hydroponic solution in a liquid form significantly had fewer leaves compared to the nutrient solution in granular form in the Diva F1 tomato cultivar but, in the Rio grande cultivar, the nutrient solution in the liquid form was found to be superior to the granular form in the number of leaves throughout the growing period. Regardless of the growing period, the lowest number of leaves were produced in liquid nutrient solution with Diva F 1 tomato cultivar.

Table 1: The pH, electrical conductivity and temperature of the nutrient solution at 0,2, 4, 6 and 8 weeks after transplanting.

Variables	Weeks after transplanting				
	0	2	4	6	8
pH	6.5	6.4	6.6	6.7	6.7
EC (dSm^{-1})	2.10	2.81	2.16	3.02	2.98
Temperature (^0C)	39.3	41.0	38.5	40.0	38.7

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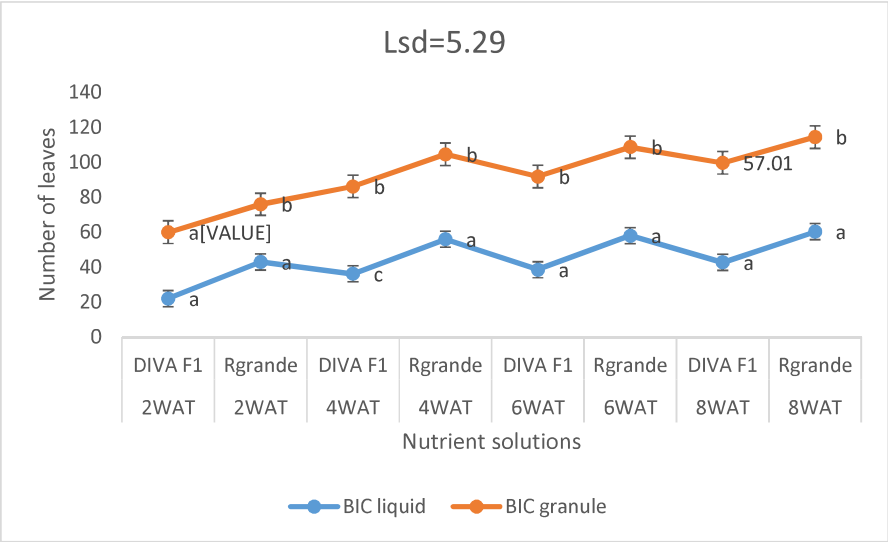


Figure 1: Interaction between the nutrient solutions on the number of leaves of tomato cultivars

The results further revealed that except at 6 WAT, there was no significant difference between the two nutrient solutions throughout the growing periods. The two cultivars had similar leaf areas at 2 and 4 WAT, but at 6 and 8 WAT, the Rio grande cultivar was superior to the Diva F 1 cultivar (Table 2). The effect of nutrient solutions on days to flowering, fruiting, stem girth, and fruit yield is presented in Table 3.The tomato cultivars in granular solution significantly took more days to attain flowering and fruiting compared with the liquid solution. Among the two cultivars, Diva F1 significantly attained flowering and fruiting earlier than the Riogrande cultivar. The granular solution was superior to the liquid solution on the stem girth as well as on the fruit yield. Similarly, the Riogrande cultivar was superior to the Diva F1 cultivar on the stem girth and on the fruit yield.

The significant interaction between the nutrient solutions and the plant height is in Figure 2. The highest plant height in Diva F1 was found to be more significant than Rio grande under granular solution throughout the growing period. In contrast, the plant height in Rio grande cultivar under liquid solution was superior to Diva F1 at all sampling periods. In addition, significantly shorter plant and smaller leaf areas were recorded in the Diva F1 cultivar under liquid nutrient solution throughout the growing period

The significant interaction between the nutrient and fruit yield is presented in Figure 3. Under the two nutrient solutions, the highest fruit yield for the two cultivars was obtained in the granular nutrient solution. In the overall, the highest fruit yield (212,707.14 kg/ha) was obtained from the Rio grande cultivar under the granular nutrient solution and the lowest fruit yield (144,528.27 kg/ha) was recorded from the Diva F1 cultivar under the liquid nutrient solution.

Table 2: The effects of nutrient solutions on leaf area at 2, 4, 6, and 8 weeks after transplanting

Treatment	Weeks After Transplanting (WAT)			
	2	4	6	8
Nutrient solutions (NUS)				
Nutrient solution (Liquid)	30.02	36.87	39.37	40.79
Nutrient solution (Granules)	33.47	33.74	42.94	47.21
LSD	4.61	3.40	0.59	8.14
Cultivars (CU)				
Diva F1	29.70	34.29	39.93	41.17
Rio grande	33.79	36.32	42.39	46.83
LSD	4.61	4.81	0.83	3.80
NUS X CU	2.2	4.81	4.16	8.14

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Table 3: The effects of Nutrient solutions on Days to flowering, fruiting, stem girth, and Fruit yield.

Treatment	DAFL	DAFR	Stem girth (cm)	Yield (kg/ha)
Nutrient solutions (NUS)				
Nutrient solution (Liquid)	43.5	48.0	4.18	157,335.50
Nutrient solution (Granule)	49.0	54.0	4.59	196,603.57
LSD	2.38	2.03	0.16	2,360.00
Cultivars (CU)				
Diva F1	42.5	48.5	3.8	162,514.0
Rio grande	50.0	53.5	4.97	191,424.9
LSD	2.38	2.03	0.16	2575.43
NUS X CU	3.37	2.87	0.22	3338.37

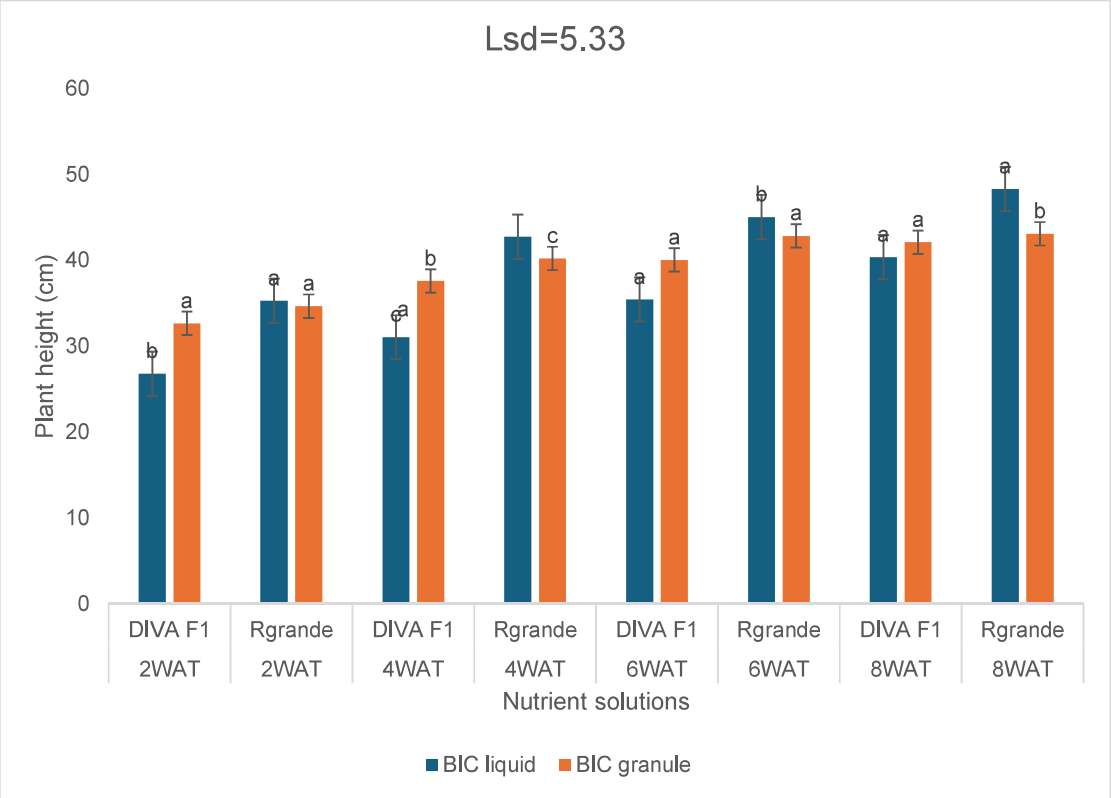


Figure 2: The Interaction between nutrient solutions and tomato cultivars on Plant height

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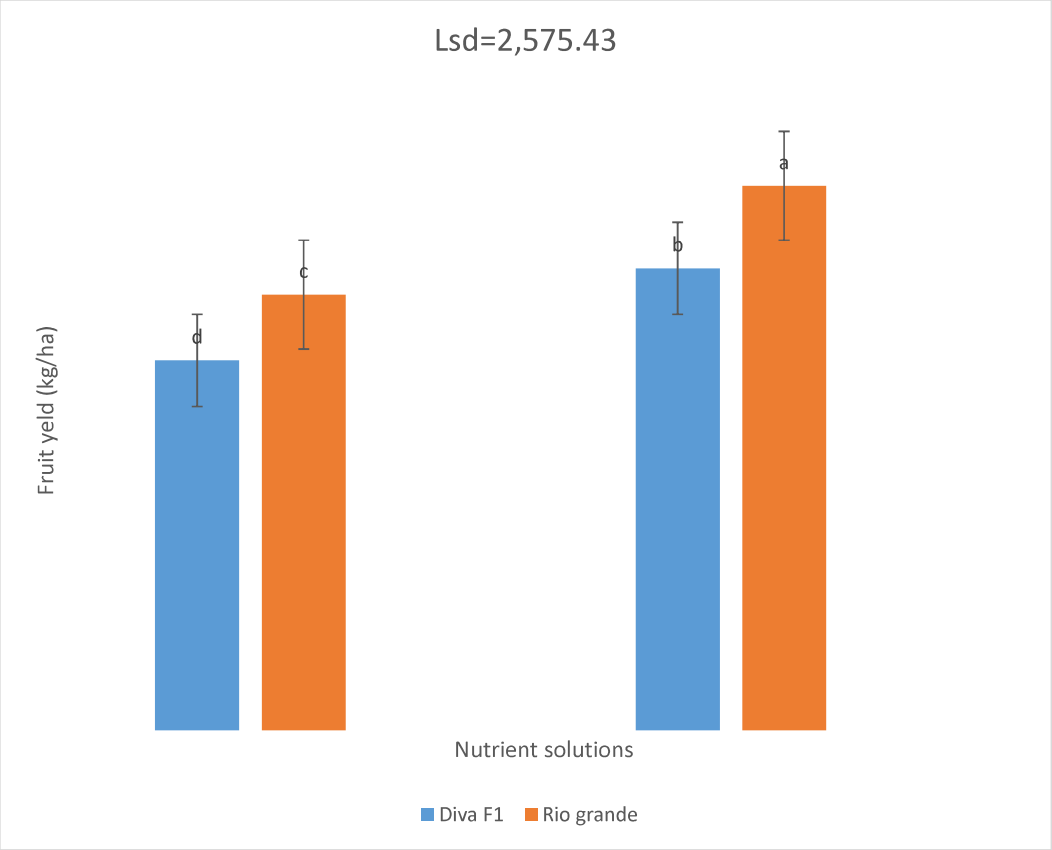


Figure 3: Interaction between nutrient solutions and fruit yield of tomato cultivars

DISCUSSION

The growth and fruit yield showed significant differences between the two tomato cultivars grown under the two nutrient solutions. This observation agreed with the findings of other researchers (Maboko *et al.,* 2011; Gashgari *et al.,* 2018; Kaushal *et a*l .2022). According to Niederwieser (2001) different tomato cultivars have different characteristics, such as sensitivity to temperature extremes, tolerance or susceptibility to insects and diseases, fruit quality and size as well as yield hence, making cultivar selection for different hydroponic production systems an important decision that can affect the tomato grower's profitability. According to Sharma *et al.* (2018), the mineral composition of tomatoes produced hydroponically is determined by the nutrients received from the growth medium, and an adequate number of nutrients is required for better production and nutrient content of tomatoes grown in the hydroponic system. In a recent study, Kausha *et al.* (2022) discovered that tomato cultivars grown in a hydroponic system showed substantial improvements in plant height, number of leaves and fruit per plant, fruit fresh weight, fruit diameter, and yield when compared to soil conditions.

The variations among the two cultivars under the two nutrient solutions could be attributed to the different characteristics of the two cultivars and variations in the strength of the nutrient solution such as pH and EC. Nutrients in the nutrient solution have great interactions that may gain either positive or negative effects on crop production, depending on crop growth stages, amounts, combinations, and balance Sheng-Xiu *et al*. (200). Chrysargyris *et al*. (2021) opined that inadequate or excessive concentrations of minerals or an imbalanced ion composition in the nutrient solution may inhibit plant development, resulting in toxicity or nutrient-induced deficiencies. The pH value of the nutrient solution greatly affects plants' growth. This is because the nutrients added to the nutrient solution are available for uptake by the plant and are soluble in water only at a particular pH (Sharma, 2018). According to Mayavan *et al*. (2017), the plants require a range of pH values to be maintained to ensure the availability of all the nutrients for uptake by the plants. Electrical conductivity gives a measure of

all the salts present in the solution without indicating the nutrient balance of the solution (Bagley *et al.,* 1997) cited in Maed (2022). In hydroponic production systems, EC management is one of the most important and manageable cultural practices that affect the visual, nutritional, and phytochemical quality of leafy vegetables (Yang *et al.,* 2021).

The observed yield of the tomato cultivars under the two hydroponic nutrients was slightly lower compared to what was obtained in other parts of the world (Olubanjo and Alade, 2018). The difference in the yield could be attributed to the period of the experiment, varietal differences, and location. During the period of the experiment, the temperature was high and was accompanied by a very low relative humidity and high solar irradiation. These environmental factors can significantly impact the productivity of tomatoes under hydroponic cultivation. According to Muthir *et al*. (2019), the temperature of the nutrient solution is considered as one of the most important determining factors of crop yield in hydroponic systems. The temperature of the nutrient solution affects the physiological process in the root, such as the absorption of water and nutrients.

CONCLUSION AND RECOMMENDATIONS

The study showed that the growth and fruit yield among the two tomato cultivars significantly differed under the two nutrient solutions. Regardless of the nutrient solution, Rio grande significantly had a higher yield than the Diva F1 cultivar. Similarly, the two cultivars under the granular solution also performed better than in the liquid solution. In the over all, the highest fruit yield was obtained from Rio grande cultivar under a granular nutrient solution. This cultivar under this nutrient solution is recommended for tomato production under a hydroponic system.

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