International Journal of Plant & Soil Science

26(4): 1-8, 2018; Article no.IJPSS.46980
ISSN: 2320-7035

Performance of *Cucurbita moschata* on Soil and Soilless Media

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Authors' contributions

This work was carried out in collaboration between all authors. Authors KO and MIO designed the study and performed the statistical analysis. Authors KO and IGU wrote the protocol and wrote the first draft of the manuscript. Authors KO and IGU managed the analyses and literature searches of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/v26i430050
Editor(s):
(1) Dr. Abhishek Naik, Technology Development Department - Vegetable Crops, United Phosphorus Limited -Advanta, Kolkata, India.
Reviewers:
(1) Paul Kweku Tandoh, Kwame Nkrumah University of Science and Technology, Ghana.
(2) Nusret Ozbay, Bingol University, Turkey.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46980

Original Research Article

Received 16 October 2018
Accepted 29 January 2019
Published 25 February 2019

ABSTRACT

Cucurbita moschata is widely grown in both tropical and temperate region due to its structural adaptability. The study was carried out to assess the performance of *C. moschata* on soil (humus) and soilless media (NPK 15:15:15 and NPK 20:10:15 growth media). These treatments are designated as T_C, T_A and T_B, respectively. Standard procedures were followed in the assessment of mineral elements, nutritional composition, pigment compositions, and morphological characters (vein length, leaf area and number of leaves) of *C. moschata* in the three treatments. Among the treatments, *C. moschata* had the highest vein length, leaf area and number of leaves in T_A, while T_C recorded the least. Nutritional compositions of *C. moschata* were: moisture content (80.10%, 87.10% and 69.50%), carbohydrate (5.34%, 3.80% and 15.00%), ash content (3.61%, 1.20% and 4.10%), crude lipid (0.60%, 0.80% and 0.60%), crude protein (8.75%, 6.56% and 8.75%) and crude fiber (1.60%, 0.34% and 2.05%) for the treatments (T_A, T_B and T_C). The mineral composition of *C. moschata* grown in T_A, T_B and T_C growth media respectively were Mg (138.15 mg/kg, 43.90 mg/kg and 109.15 mg/kg), Mn (73.35 mg/kg, 0.25 mg/kg and 123.30 mg/kg), K (2,892.30 mg/kg, 3,338.80 mg/kg and 1,950.80 mg/kg), Zn (47.60 mg/kg, 10.55 mg/kg, 34.00 mg/kg), Ca (2,731.50 mg/kg,

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337.95 mg/kg and 426.30 mg/kg), Na (89.65 mg/kg, 108.15 mg/kg and 66.60 mg/kg) and Fe (211.25 mg/kg, 0.00 mg/kg and 137.55 mg/kg) while copper was not detected. The pigment contents indicated the presence of chlorophyll *a* (0.32 mg/g, 0.39 mg/g and 0.24 mg/g), chlorophyll *b* (0.46 mg/g, 0.64 mg/g and 0.40 mg/g), carotenoid (0.33 mg/g, 0.42 mg/g and 0.30 mg/g), and xanthophyll (0.05 mg/g, 0.10 mg/g and 0.00 mg/g) for the three treatments, respectively. The study recommends the use of NPK 15:15:15 solution in a soilless condition and the inclusion of NPK 15:15:15 to the soil to improve the performance of *Cucurbita moschata.*

Keywords: Pumpkin; growth; development; minerals.

1. INTRODUCTION

The production of vegetables and food for human consumption by many subsistent farmers has largely depended on soil as the growth medium. This means of production accounts for majority of vegetables such as *Telfairia occidentalis*, *Cucurbita moschata*, and *Talinum triangulare* found in our local markets. The volumes of production of vegetables have declined in recent years in rural and urban areas due to anthropogenic activities and reduction in soil fertility. However, the advent of scientific research led to the cultivation of plants in a soilless medium like hydroponics. According to Kumar and Cho, hydroponic is a technology which aids plant growth in nutrient solution involving or excluding the application of external source for provision of mechanical support [1]. It was earlier reported by Jensen that production of food in soilless medium is on the increase all over the world [2]. In addition, hydroponically grown vegetables and fruits have been recorded in literature as possessing more nutritional and desirable values as compared to soil grown food produce [3,4,5,6]. The seedlings quality and vigour is dependent on the composition of media used [7,8,9,10]. Most research carried out on hydroponic has been geared towards leafy greens, peppers and tomato fruit [6,11,12], while research on hydroponically grown *C. moschata* has been scarce.

Cucurbita moschata (Duschene *ex* Lam.) Duschene *ex* Poir belongs to the family Cucurbitaceae. Cucurbitaceae ranks amongst the highest of plant families used as human food, cultivated in tropics and temperate regions [13]. *C. moschata* possesses nutritional and therapeutic qualities and has gained the attention of food scientists in recent time [14]. The seeds of *C. moschata* are rich in minerals [15], useful source of nutrients and oils [16] and thus could be used as valuable food supplement [15,17]. *C. moschata* as fruit vegetable is rich in carotenoids which have antioxidant activities and are easily converted to retinol, the active form of vitamin A [18,19]. Beta carotene is the most predominant and active of the 5 or 6 provitamins present in commonly consumed foods [20]. It is locally consumed as freshly boiled and steamed or as processed food items in Thailand [21] and in cuisine or serve as desert in Malaysia [22]. There is also a wide variety carotenoid content of food from different races [23]. *C. moschata* is cultivated in Nigeria for both the fruits and leaves [24,25].

In line with the challenges of population dynamics round the globe and the reduction in arable land for the cultivation of plants, the study is aimed at evaluating the growth and development of *C. moschata* on both soil and soilless media and proffers information in order to enhance its production for both human consumption and profit making.

2. MATERIALS AND METHODS

The study was carried out within July – November 2017 and in a non-circulating hydroponics system [dimensions: 29 cm (width) x 41 cm (length) x 23 cm (depth)] in the screen house of Ecological Center, University of Port Harcourt.

2.1 Source of Materials Used

The seeds of *C. moschata* were collected from the Ecological Center of the University of Port Harcourt. The seeds were divided into two batches and planted in white-sand and humus soil, respectively. The medium of growth for the seedling were humus-soil (T_C) and two NPK solution formulations (15:15:15 and 20:10:15) designated as T_A and T_B, respectively. The electrical conductivity, pH and total dissolved solutes of the solutions were 15.9 µs/cm, 5.5, 10.18 ppm for NPK 15:15:15 and 14.8 µs/cm, 5.3, 9.47 ppm for NPK 20:10:15, respectively. The two-week old seedlings raised with white-sand were transferred to hydroponic bowls containing different solutions of NPK formulation (T_A and T_B), which served as the soilless medium. The seedlings raised with humus soil served as the soil medium (T_C). The plants were allowed to stand for 8 weeks after planting. The morphological characters of *C. Moschata* assessed were the vein length, number of leaves and leaf area. Minerals, pigment content and proximate composition of the leaves were determined following standard procedures.

2.2 Morphological Characters

Vein length of *C. moschata* was measured with meter rule calibrated in centimeters while the number of leaves was obtained by direct counting. The leaf area of *C. moschata* was determined using the method of Akoroda [26]. Estimated leaf area (LA) = 0.9467 + 0.2475LW + 0.9724LWN

Where,

N = Number of leaflets in a leaf;
L = Length of the central length;
W = Maximum width of the central leaflet.

2.3 Proximate Composition

The proximate composition (crude protein, carbohydrate, crude fibre, crude lipid, ash and moisture contents) of *C. moschata* was determined using method of Association of Official Analytical Chemists [27].

2.4 Mineral Content

The mineral contents (Mg, Cu, Mn, K, Zn, Ca, Na and Fe) of *C. moschata* were determined using Atomic Absorption Spectrophotometer (AAS).

2.5 Pigment Content

Sample (0.1 g) *C. moschata* was transferred into a test tube and acetone was added to make it up to 10 ml. The test tube was then kept in the dark for 15 minutes with occasional shaking at room temperature. The chlorophyll, carotenoid and xanthophyll contents were analyzed spectrophotometrically by absorption measurement (*A*) at 350 nm to 700 nm with 1 nm interval and calculated according to the following equations:

$$\text{Chlorophyll } a \text{ (mg/g)} = \frac{13.7 \text{ x A665} - 5.76 \text{ x A649}}{\text{Mass x 200}}$$

$$\text{Chlorophyll } b \text{ (mg/g)} = \frac{25.8 \text{ x } A649 - 7.6 \text{ x } A665}{\text{Mass x 200}}$$

$$\text{Carotenoid } \left(\frac{\text{mg}}{\text{g}}\right) = \frac{4.7 \text{ x } A440 - 0.263 \text{ x Chlorophyll (a + b)}}{\text{Mass x 200}}$$

$$\text{Xanthophyll (mg/g)} = \frac{11.51 \text{ x } A480 - 20.61 \text{ x } A495}{\text{Mass x 200}}$$

The above pigments were extracted using acetone according to established methods [28,29,30].

2.6 Statistical Analysis

The data obtained for the morphological characters and pigment contents of *C. moschata* were subjected to statistical analysis using Microsoft Excel 2010 at 95% confidence level.

3. RESULTS AND DISCUSSION

3.1 Morphological Characters

3.1.1 Vein length

The vein lengths of *C. moschata* grown in three different media are presented in Fig. 1. There was an increase in vein length from week 2 – 8 for the treatments. However, T_A medium gave the highest vein length (13.25 cm) compared to other treatments (11.15 cm and 9.10 cm) at 8th week. The least vein length (9.10 cm) was recorded in the soil treatment at 8th week.

3.1.2 Leaf area

The leaf area of *C. moschata* grown in three different media is presented in Fig. 2. There was an increase from week 2 – 8 for the treatments, T_A treatment had the highest leaf area (74.35 cm^2) compared to other treatments (67.05 cm^2 and 58.85 cm^2) at 8th week. The least leaf area (58.85 cm^2) was recorded in the T_C treatment at 8th week. This study has shown that the proportion of nitrogen, phosphorus and potassium available in the growth medium affects directly or indirectly the leaf area of plants.

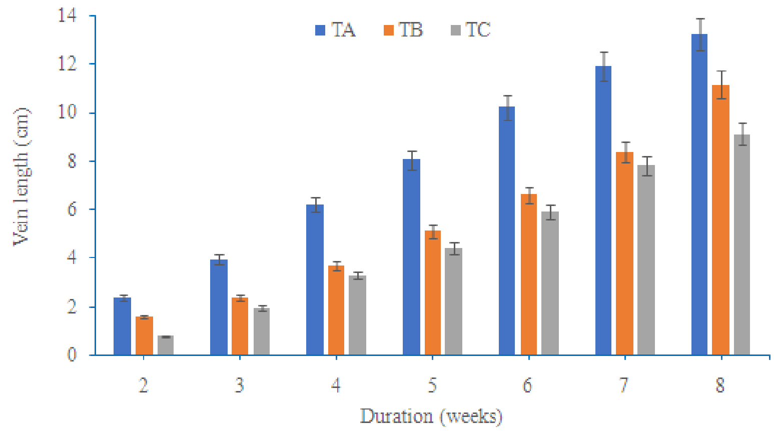

Fig. 1. Vein length (cm) of *C. moschata* in three different growth media

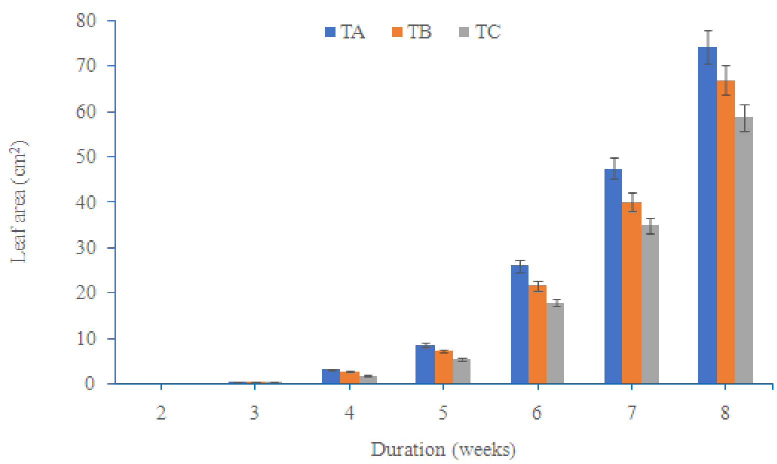

Fig. 2. Leaf area (cm^2) of *C. moschata* in different growth media

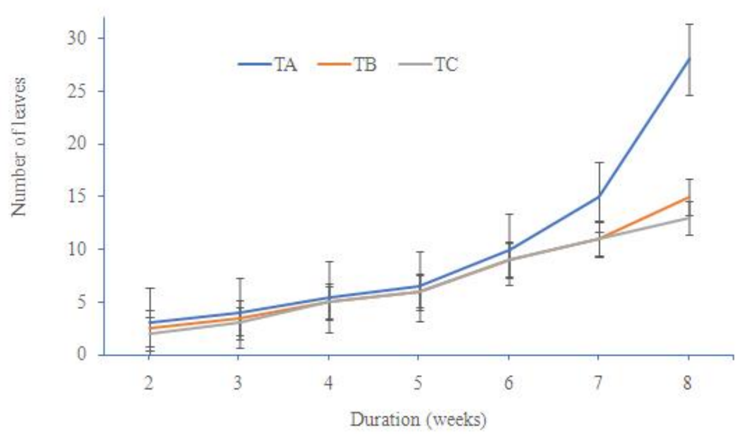

Fig. 3. Number of leaves of *C. moschata* in three different growth media

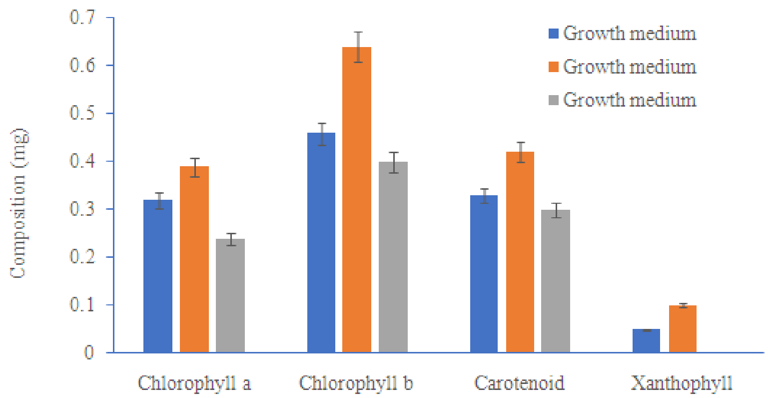

Fig. 4. Pigment content (mg) of *C. moschata* in three different growth media

3.1.3 Number of leaves

The number of leaves of *C. moschata* grown in three different media is presented in Fig. 3. From week 2 – 8, there was continuous increase in number of leaves among the three treatments (T_A, T_B and T_C). This observation is expected of growing plants. However, there was variation in the number of leaves of *C. moschata* in different treatments. At week 8, the highest increase in number of leaves was observed in T_A growth medium while the least recorded in T_C treatment. Apart from other factors that may interfere in plant growth, Nugawela et al. [31] reported a correlation between CO_2 assimilation rate and planting conditions. Plants experiences reduced dry biomass and this affects vegetative growth due to the reduction in CO_2 assimilation rate when planted under artificial shade such as green or shelter house. On the other hand, container and media interaction may affect fertility, pH, soluble salts, bulk density and root zone volume [32]. These may greatly influence plant growth on soilless substrate. However, the study has shown that the number of leaves of *C. moschata* was enhanced in soilless media containing varied proportion of NPK.

3.2 Proximate Compositions

The proximate composition of *C. moschata* leaves showed high amount of moisture content (80.10%, 87.10% and 69.50%) for T_A, T_B and T_C treatments, respectively. The carbohydrate contents were 5.34%, 3.80% and 15.00% in that order. Others were: ash (3.61%, 1.20 % and 4.10%), protein (8.75%, 6.56% and 8.75%) and crude fibre (1.60%, 0.34% and 2.05%) were considerably low. The lipid contents (0.60%, 0.80% and 0.60%) were the lowest. The moisture and lipid contents were highest in *C. moschata* grown in T_B treatment. Ihenacho and Udebuani had earlier reported that high percentage moisture content provides for greater activity of water soluble enzymes and co-enzymes needed for metabolic activities [33]. Dietary fibre has some physiological effects in the gastro-intestinal tract such as: elimination of bile acids, fecal water [34]. It also serves as a source of human nutrition for diabetics in order to reduce glycaemic response to food and consequently the need for insulin [35]. Protein is an important part of catalytic activities, membrane build-up [36,37]. The nutrient composition of plant materials varies with season, environment, age and cultural practice [38].

3.3 Mineral Compositions

Cucurbita moschata leaves contain different minerals and their compositions ranging from lower concentrations of Zinc (Zn): 47.60 mg/kg, 10.55 mg/kg, and 34.00 mg/kg; Manganese (Mn): 73.35 mg/kg, 0.25 mg/kg, and 123.30 mg/kg; Sodium (Na): 89.65 mg/kg, 108.15 mg/kg, and 66.60 mg/kg; Magnesium (Mg): 138.15 mg/kg, 43.90 mg/kg and 109.15 mg/kg; Iron (Fe): 211.25 mg/kg, 0.00 mg/kg, and 137.55 mg/kg for T_A, T_B and T_C treatments, respectively. Higher concentrations of mineral element were evident in Potassium (K): 2,892.30 mg/kg, 3,338.80 mg/kg, and 1,950.80 mg/kg respectively. In the three growth-media, Calcium (Ca) was highest in T_A medium (2,731.50 mg/kg). Copper content was not detected in the three growth-media. The role of these elements in the well-being of humans has been previously documented by previous workers [39]. Mineral element plays diverse but essential role in plants, some of which include: catalytic, structural and electrochemical [37]. This implies that the consumption of *C. moschata* leaves will help to improve the nutritional status of human-beings.

3.4 Pigment Content

The leaves of *C. moschata* had the highest composition of chlorophyll *a* and chlorophyll *b* in T_B medium, 0.39 mg and 0.64 mg respectively. The concentration of carotenoid and xanthophyll also had the highest concentration in T_B medium, 0.42 mg and 0.10 mg respectively, as shown in Fig. 4. and higher than xanthophyll content in the growth media. Among the pigments, chlorophyll *b* content was in abundance than others in all the treatments. The carotenoids obtained in the leaves of *C. moschata* were in line with the work of Pritwani and Manthur, that reported the carotenoids value of 0.407 mg [40]. This trend could be associated with higher nitrogen content. Leaf growth, leaf area and photosynthetic rate may be influenced by the level of N in the soilless media. This ensures control of photosynthetic elements and production of carbohydrates. There may be probably a strong correlation and influence between chlorophyll and leaf area because the former indicates some level of N accumulation in leaves [41]. More so nitrogen use efficiency is said to be attributed to leaf area and other growth traits such as plant height [42]. Increase in N and P could increase leaf growth and chlorophyll content while its decrease may also be detrimental to crops [43]. Though, concentration of these elements sometimes may be advantageous or detrimental to the plants [44]. Other factors which may equally stimulate plant growth and development are better gaseous exchange; improved drainage and uniform extension of root systems sometimes are more advantageous than other growth factors [45].

4. CONCLUSION

Cucurbita moschata is rich with nutrient and mineral composition. The mineral composition of any growth medium determines the growth and development of *C. moschata.* The study has shown that the variation in the macro-nutrients affects the vigour of *C. moschata.* T_A medium gave the highest vein length, leaf area, and number of leaves of *C. moschata* while the pigment compositions were slightly higher in T_B medium compared to other treatments. The study therefore recommends that *C. moschata* be grown in a moderate concentration of NPK solution with a view of tackling the problem of reduction in soil fertility and non-availability of arable land for the cultivation of *C. moschata*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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