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Growth of *Telfairia occidentalis* Leaf Grown in NPK 20-10-10 Hydroponic Solution

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Abstract

Optimization of nutrient conditions and growth of *Telfairia occidentalis* Hooker fil in a hydroponic system was the focus of this study. The study evaluated the growth of *T. occidentalis* under varying growth media subject to the amount of NPK 20-10-10 granules (25 g, 50 g, 75 g, 100 g, 125 g, and 150 g, respectively) dissolved in water containing micronutrients. The growth media were M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK, M^{150}NPK, and Control. Two-week-old seedlings of *T. occidentalis* raised using River-sand were transferred into the growth media; in four replicates. The growth indices [vine main length (VML), number of leaves (NL), stem girth (SG), petiole length (PL), internode (LI), leaf area (LA), and total leaf area (TLA)] of *T. occidentalis* were measured weekly. The root length (RL), root fresh weight (RFW), root dry weight (RDW), and pigment components were determined 5 weeks after planting (WAP) following standard procedures. The results recorded indicated that the average pH value (6.74) and sulphate content (0.047 ppm) of the growth media increased while the electrical conductivity (94.443 µS) reduced after 28 days. The proportion of the minerals varied in the hydroponic solutions. Across the growth media, the Control medium had the highest VML, NL, LA, TLA, PL, and pigment composition of *T. occidentalis*. However, among the NPK growth media, the M^{25}NPK medium effectively enhanced VML, NL, LA, TLA, carotenoid content, RL, RFW, and RDW. The study showed that the mineral composition of the growth media enhanced the growth of *T. occidentalis*. Hence, M^{25}NPK growth media are recommended for growing *T. occidentalis*.

Keywords

Growth, Growth Media, Optimization, *Telfairia occidentalis*

1. Introduction

Plants are generally seen growing either in terrestrial or aquatic ecosystems de-

pending on their habits. Soil and water function as a natural media for growing plants in terrestrial and aquatic ecosystems, respectively. Soil properties such as nutrient levels, salinity, acidity, microbial load, and particle size differ from one area to another. These soil properties usually to a great extent determine the vigour and nutritional value of cultivated crops. John *et al.* [1] documented that sufficient application of nitrogen to plants is linked with increased photosynthetic activity, strong asexual growth, and dark green pigmentation of the leaves. Also, according to Pandey and Sinha [2], nitrogen plays a significant part in processes such as nucleic acid activities, chlorophyll, and protein syntheses. Phosphorus is vital for photosynthesis and growth while potassium supports enzyme activities [3]. Potassium does not form any organic compounds in the plant; however, its presence is needed for plant growth due to its function as an enzyme activator that promotes metabolism [4]. Poor soil fertility has steered the introduction of inorganic fertilizer to augment the soil fertility status and its usage has affected adversely on the soil and consequently the plant growth due to an increase in soil acidity, nutrient discharge, decomposition of the soil's organic material, and physical environments [5].

Furthermore, the accessibility of land for the cultivation of crops has decreased greatly with time due to anthropogenic activities on the terrestrial ecosystem geared towards enhancement and improvement of the human race. This condition is evident in most places like metropolitan areas, where the soil is not accessible for farming crops at all while some areas have a scarcity of fertile soil as a result of unfavourable geographical or topographical conditions [6]. Sardare and Admane [7] reported that as a result of fast development and industrialization, arable lands under cultivation will further decrease with time.

Unfortunately, Farmers are challenged with a shortage of fertile arable land for cultivation coupled with bush fallowing which limits their acquisition of land for cultivation. Irrigation farming for active and maintainable crop production in the Niger Delta is rarely practiced. According to Fubara-Manuel *et al.* [8], Niger Delta is categorized by separate rainy and dry periods in a year, and agriculturalists grow crops at a subsistence level only during the rainy period. However, Fubara-Manuel [9] earlier noted that even within the rainy period, particularly in May and June, crops may yet be affected by water stress as a result of inadequate soil water available at the root zone. This condition is also worsened by oil pollution which has become a regular occurrence in some areas of the Niger Delta. A scenario that demands an alternative approach to maintaining the food chain. One of the alternatives to growing food without soil is called hydroponics. It has a positive connotation among consumers and producers due to the purported environmental benefits it can offer [10]. The frequent use of this hydroponic technology will help to determine which crop is suitable to be grown in hydroponic systems [11]. Inadequate access to food, especially fresh food and vegetables, is a public health concern because the intake of fruits and vegetables is linked with reduced the danger of certain protracted illnesses [12] [13]. Hence, making vegetables available should be a priority to any government or nation

which serves as source of nutrients to human beings. This study is aimed at using NPK 20-10-10 fertilizer in the formulation of locally hydroponic nutrient solutions for growing *T. occidentalis.*

2 Materials and Methods

Source of materials: The seeds of fluted pumpkin used were sourced from Choba Market and the River-sand was obtained from Choba-River Port Harcourt (4˚54'0"N 6˚54'0"E) while the NPK 20:10:10 fertilizer used was produced by Unique Fertilizer Company Nigeria and obtained from Agricultural Development Programme, Rumuodumaya Port Harcourt.

Formulation of the nutrient solution: The method of Kratky [14] was used with modification in nutrient formulation and container used. NPK 20:10:10 granular fertilizers were weighed (25 g, 50 g, 75 g, 100 g, 125 g, and 150 g, respectively) and transferred into black plastic bowls with the dimensions: 29 cm width, 41 cm length, and 23 cm depth. The same was dissolved with 20 litres of tap water in the plastic bowls leaving space for aeration with the addition of 20 ml micronutrients stock solution (0.6 g H_3BO_3; 0.4 g $MnCl_2{\cdot}4H_2O$; 0.05 g $ZnSO_4$; 0.5 g $CuSO_4{\cdot}5H_2O$; 0.02 g $Na_2MoO_4{\cdot}2H_2O$) and Epsom salt (9.8 g $MgSO_4$). The Control medium (water) was set up without the addition of Urea, micronutrients, and Epsom salt. These formulations were replicated four times. The growth media were M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK, M^{150}NPK, and Control (0 g) depending on the amount of NPK 20:10:10 dissolved in water.

Study site and weather condition: The study was conducted in a screen house inside the University of Port Harcourt (Lat. N4˚54'15", Long. E6˚54'35"). The site was free from direct rainfall and was open to sunlight any time of the day. The screen house had a transparent cover that permits light penetration and hinders direct rainfall. During the period of the experiment, the weather condition of the University was relatively wet with the daytime temperature that ranges from 24˚C in the early morning to 32˚C in the middle part of the day.

Planting of *T. occidentalis*: The seeds of *T. occidentalis* were planted in nursery bags containing River-sand as a medium for germination to take place. After germination, the two weeks old seedlings (17 - 20 cm) from the River-sand were transferred into the non-circulating hydroponic systems containing different formulations of nutrient solution. The components of the nutrient solutions were sourced locally.

Growth indices measurement: The vine length, petiole length and internode were measured using meter rule while the number of leaves was by direct count. The leaf area was determined following the method of Akoroda [15]. The vine girth was determined with the aid of electronic digital caliper (Carbon Fiber Composites Digital Caliper).

Pigment content: The chlorophyll content was obtained according to the method of Poora [16] while the carotenoid content was determined following the method of Sumanta *et al.* [17].

Statistical analysis: The data obtained for the morphological characters and pigment contents of fluted pumpkin were subjected to statistical analysis. Statistical Analysis System (SAS) version 9.0 was used to carry out the two-way analysis of variance (ANOVA) of the data to ascertain significant difference at $P = 0.05$ between the treatment means and within each treatment means. Duncan Multiple Range Test (DMRT) was used for mean separation where significant different ($P \leq 0.05$) existed.

3. Results

Vine main length of *T. occidentalis* grown in different growth media: The results of the investigation of different NPK growth media on the vine main length of *T. occidentalis* are presented in Table 1. There was increase in vine main length (VML) from week 3 - 5 across growth media. The VML value was higher in M^{50}NPK medium compared to other media for the week 3 - 4 and was also significantly different ($P = 0.05$) from other media except the Control and M^{25}NPK medium. After the fourth week, there was exponential increase in VML value for Control and M^{25}NPK media, respectively. The percentage increase in VML values were 99.27%, 54.45%, 0.48%, 3.40%, 12.75%, 0.91% and 1.86% for Control, M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK and M^{150}NPK media, respectively. At week 3, the Control medium (57.05 ± 18.018 cm) had the highest VML value, followed by M^{25}NPK medium (45.33 ± 16.224 cm) in that order and this difference in VML was significant. It was also evident that as the NPK concentration in the medium increases the VML value decreases. The lowest VML value was obtained at M^{150}NPK.

Stem girth of *T. occidentalis* grown in different growth media: The stem girth (mm) of *T. occidentalis* grown in varying concentration of NPK solutions

Table 1. Vine main length (cm) of *T. occidentalis* in different NPK growth media.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	23.23 ± 5.752^{a}	28.63 ± 10.036^{ab}	57.05 ± 18.018^{a}	36.300^{a}
M^{25}NPK	23.33 ± 3.085^{a}	29.35 ± 3.781^{ab}	45.33 ± 16.224^{ab}	32.667^{a}
M^{50}NPK	23.63 ± 3.567^{a}	37.75 ± 12.301^{a}	37.93 ± 12.253^{bc}	33.100^{a}
M^{75}NPK	18.98 ± 2.034^{a}	20.00 ± 6.238^{b}	20.68 ± 6.490^{c}	19.883^{b}
M^{100}NPK	21.35 ± 4.397^{a}	22.35 ± 5.157^{b}	25.20 ± 6.647^{c}	22.967^{b}
M^{125}NPK	19.80 ± 3.445^{a}	21.93 ± 5.572^{b}	22.13 ± 5.171^{c}	21.283^{b}
M^{150}NPK	20.05 ± 4.843^{a}	21.55 ± 7.223^{b}	21.95 ± 7.520^{c}	21.183^{b}
Mean	21.479 ± 3.996^{b}	26.032± 9.010^{b}	32.796± 16.790^{a}	
$LSD_{(P=0.05)}$	5.9372	11.368	16.715	7.4766

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

is shown in Table 2. The rate at which the stem girths increased was minimal across and within growth media from weeks 3 - 5. The ranges within media were: Control (4.55 - 5.35 mm), M^{25}NPK (4.87 - 5.00 mm), M^{50}NPK (4.38 - 5.30 mm), M^{75}NPK (2.90 - 4.23 mm), M^{100}NPK (2.58 - 3.95 mm), M^{125}NPK (4.23 - 5.00 mm) and M^{150}NPK (4.25 - 5.00 mm). Amongst growth media, the percentage increment in stem girth was 17.58%, 3.09%, 21.00%, 45.86%, 58.10%, 18.20% and 17.65% for Control, M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK and M^{150}NPK growth media, respectively. M^{100}NPK medium had the highest percentage increase of stem girth from week 3 - 5. However, at week 5, the highest value for stem girth (5.35 ± 0.370 mm) was obtained at Control medium and this was not significantly different ($P \leq 0.05$) compared to other growth media except M^{100}NPK medium while the lowest stem girth value was 3.95 ± 0.580 mm at M^{100}NPK growth medium.

Number of leaves of *T. occidentalis* grown in different growth media: Table 3 shows the number of leaves of *T. occidentalis* grown in varying NPK growth media. The number of leaves reduced with increased NPK concentrations in the growth media. However, M^{75}NPK medium had higher number of leaves than M^{100}NPK medium. Amongst growth media from weeks 3 - 5, the percentage increase in number of leaves was 34.38%, 23.33%, 17.86%, 7.69%, 11.54%, 4.35% and 4.35% for Control, M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK and M^{150}NPK media, respectively. Control medium had the highest percentage increase for number of leaves from weeks 3 - 5, followed by M^{25}NPK growth medium. Hence, the highest mean value for number of leaves (10.75 ± 0.957) was recorded at the Control medium and it was significantly different from other growth media except for M^{25}NPK medium while the lowest (6.00 ± 0.816 and 6.00 ± 1.414) at M^{150}NPK and M^{125}NPK growth media, in that order at

Table 2. Stem girth (mm) of *T. occidentalis* in different NPK growth media.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	4.55 ± 0.635^{a}	4.65 ± 0.785^{ab}	5.35 ± 0.370^{a}	4.8500^{a}
M^{25}NPK	4.87 ± 0.843^{a}	5.00 ± 0.971^{a}	5.00 ± 0.408^{ab}	4.9083^{a}
M^{50}NPK	4.38 ± 0.732^{ab}	4.58 ± 0.395^{ab}	5.30 ± 0.440^{a}	4.7500^{a}
M^{75}NPK	2.90 ± 1.095^{bc}	3.00 ± 1.111^{c}	4.23 ± 1.115^{ab}	3.3750^{b}
M^{100}NPK	2.58 ± 0.763^{c}	3.68 ± 0.287^{bc}	3.95 ± 0.580^{b}	3.4000^{b}
M^{125}NPK	4.23 ± 1.209^{ab}	4.30 ± 0.560^{ab}	5.00 ± 0.716^{ab}	4.5083^{a}
M^{150}NPK	4.25 ± 0.995^{ab}	4.48 ± 1.446^{ab}	5.00 ± 1.061^{ab}	4.5750^{a}
Mean	3.9786 ± 1.1818^{b}	4.2250 ± 0.9489^{b}	4.8107 ± 0.8504^{a}	
$LSD_{(P=0.05)}$	1.3984	1.1796	1.147	0.628

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

week 5.

Leaf petiole length of *T. occidentalis* grown in different growth media: The leaf petiole length (LPL) of *T. occidentalis* grown in varying concentrations of NPK growth media varied across growth media (Table 4). The rate at which the petiole lengths increased was minimal across and within growth media from weeks 3 - 5. The ranges within growth media were: Control (3.90 - 4.90 cm), M^{25}NPK (3.18 - 4.70 cm), M^{50}NPK (3.95 - 4.93 cm), M^{75}NPK (4.25 - 4.40 cm), M^{100}NPK (3.10 - 3.83 cm), M^{125}NPK (2.35 - 3.18 cm) and M^{150}NPK (2.95 - 4.30 cm). Amongst growth media, the percentage increase in the petiole lengths was

Table 3. Number of leaves of *T. occidentalis* in different NPK growth media.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	8.00 ± 0.816^{a}	8.75 ± 0.500^{a}	10.75 ± 0.957^{a}	9.1667^{a}
M^{25}NPK	7.50 ± 1.291^{ab}	8.25 ± 0.957^{ab}	9.25 ± 2.062^{ab}	8.3333^{ab}
M^{50}NPK	7.00 ± 2.944^{ab}	7.50 ± 1.915^{ab}	8.25 ± 2.500^{bc}	7.5833^{bc}
M^{75}NPK	6.50 ± 1.291^{ab}	7.00 ± 1.633^{ab}	7.00 ± 1.414^{bc}	6.8333^{cd}
M^{100}NPK	6.50 ± 0.577^{ab}	7.25 ± 0.957^{ab}	7.25 ± 0.957^{bc}	7.0000^{c}
M^{125}NPK	5.75 ± 1.258^{b}	6.00 ± 1.414^{b}	6.00 ± 1.414^{c}	5.9167^{d}
M^{150}NPK	5.75 ± 0.500^{b}	6.00 ± 0.816^{b}	6.00 ± 0.816^{c}	5.9167^{d}
Mean	6.7143 ± 1.5119^{b}	7.3571 ± 1.6151^{ab}	7.6786 ± 2.0737^{a}	
$LSD_{(P=0.05)}$	2.1406	2.0547	2.1103	1.0547

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

Table 4. Petiole length (cm) of *T. occidentalis* leaves in different NPK growth medium.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	3.90 ± 1.052^{a}	4.20 ± 1.071^{a}	4.90 ± 0.383^{a}	4.3333^{a}
M^{25}NPK	3.18 ± 1.345^{ab}	3.90 ± 0.346^{ab}	4.70 ± 0.560^{a}	3.9250^{ab}
M^{50}NPK	3.95 ± 0.755^{a}	4.20 ± 0.668^{a}	4.93 ± 0.150^{a}	4.3583^{a}
M^{75}NPK	4.25 ± 0.954^{a}	4.30 ± 0.600^{a}	4.40 ± 0.779^{ab}	4.3167^{a}
M^{100}NPK	3.10 ± 0.808^{ab}	3.73 ± 0.838^{ab}	3.83 ± 0.403^{ab}	3.5500^{b}
M^{125}NPK	2.35 ± 0.473^{b}	3.05 ± 0.900^{b}	3.18 ± 1.021^{b}	2.8583^{c}
M^{150}NPK	2.95 ± 0.777^{ab}	4.20 ± 0.560^{a}	4.30 ± 1.388^{ab}	3.8167^{ab}
Mean	3.4036 ± 1.0330^{b}	4.0464 ± 0.7758^{a}	4.1893 ± 0.9589^{a}	
$LSD_{(P=0.05)}$	1.3159	0.9480	1.3051	0.644

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

25.64%, 27.72%, 24.81%, 3.53%, 23.55%, 35.32% and 42.37% for the Control, M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK and M^{150}NPK media, respectively. Percentage increase in LPL from weeks 3 - 5 was highest in M^{150}NPK medium. However, the highest value for leaf petiole length (4.93 ± 0.150 cm) was recorded at M^{50}NPK medium and it was not significantly different from other growth media except for M^{125}NPK medium while the lowest value for LPL was 3.18 ± 1.021 cm at M^{125}NPK medium at week 5.

Leaf internodes of *T. occidentalis* grown in different growth media: Table 5 shows the growth performance of *T. occidentalis* leaf internodes (cm) in different NPK growth media for 5 weeks. There was increase in leaf internodes from weeks 3 - 5 across growth media. The leaf internodes value was higher in the Control medium compared to other media for weeks 3 - 4 after seedlings were transferred into the growth media except in week 4 (M^{125}NPK). After week 2, there was rapid increase in leaf internodes value for M^{75}NPK medium. After week 4, the percentage increase in leaf internodes values was 1.78%, 7.83%, 11.03%, 53.82%, 17.57%, 6.03% and 3.51% for Control, M^{25}NPK, M^{50}NPK, M^{75}NPK, M^{100}NPK, M^{125}NPK and M^{150}NPK growth media, respectively. At week 5, the M^{75}NPK medium (5.23 ± 2.188 cm) had the highest leaf internodes mean value, followed by M^{50}NPK medium (4.83 ± 1.609 cm). The lowest mean value for leaf internodes (3.83 ± 1.228 cm) was recorded at M^{150}NPK.

Leaf area of *T. occidentalis* grown in different growth media: The results of the evaluation of different NPK growth media on the leaf area of *T. occidentalis* are shown in Table 6. There was an increase in the leaf area from week 3 - 5 and the growth performance varied across the growth media. The leaf area ranged from 110.28 - 138.00 cm^2, 117.00 - 132.68 cm^2, 118.31 - 122.28 cm^2, 113.94 - 122.80 cm^2, 95.18 - 106.75 cm^2, 84.96 - 108.77 cm^2, and 90.97 - 127.24

Table 5. Internode (cm) of *T. occidentalis* leaves in different NPK growth medium.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	4.40 ± 1.444	4.50 ± 2.380[a]	4.58 ± 0.419	4.4917[a]
M^{25}NPK	3.70 ± 1.707	3.83 ± 1.372[a]	4.13 ± 0.900	3.8833[a]
M^{50}NPK	4.33 ± 1.972	4.35 ± 2.744[a]	4.83 ± 1.609	4.5000[a]
M^{75}NPK	3.30 ± 1.579	3.40 ± 0.952[a]	5.23 ± 2.188	3.9750[a]
M^{100}NPK	3.65 ± 1.277	3.70 ± 1.160[a]	4.35 ± 0.520	3.9000[a]
M^{125}NPK	3.00 ± 1.068	4.48 ± 2.164[a]	4.75 ± 1.994	4.0750[a]
M^{150}NPK	3.40 ± 2.051	3.70 ± 0.589[a]	3.83 ± 1.228	3.6417[a]
Mean	3.683	3.994 ± 1.6996	4.529	
$LSD_{(P=0.05)}$		2.736		2.1442

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

Table 6. Leaf area (cm^2) of *T. occidentalis* in different NPK growth media.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	110.28 ± 5.576[a]	124.39 ± 14.924[a]	138.00 ± 17.617[a]	124.22[a]
$M^{25}NPK$	117.00 ± 26.938[a]	119.07 ± 25.673[a]	132.68 ± 48.723[a]	122.91[a]
$M^{50}NPK$	118.31 ± 43.030[a]	119.16 ± 39.376[a]	122.28 ± 52.751[a]	119.92[ab]
$M^{75}NPK$	113.94 ± 22.811[a]	119.48 ± 17.759[a]	122.80 ± 43.603[a]	118.74[ab]
$M^{100}NPK$	95.18 ± 19.896[a]	101.67 ± 25.215[a]	106.75 ± 25.275[a]	101.20[ab]
$M^{125}NPK$	84.96 ± 21.366[a]	88.96 ± 23.648[a]	108.77 ± 16.493[a]	94.23[b]
$M^{150}NPK$	90.97 ± 23.147[a]	124.21 ± 29.013[a]	127.24 ± 22.477[a]	114.14[ab]
Mean	104.374 ± 25.8451[b]	113.847 ± 26.2803[ab]	122.645 ± 33.0900[a]	
$LSD_{(P=0.05)}$	37.353	38.445	52.092	27.362

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

cm^2 for Control, $M^{25}NPK$, $M^{50}NPK$, $M^{75}NPK$, $M^{100}NPK$, $M^{125}NPK$ and $M^{150}NPK$ growth media, respectively. The Control medium had the highest leaf area value (138.00 ± 17.617 cm^2) at week 5, followed by $M^{25}NPK$ medium (132.68 ± 48.723 cm^2) while the lowest value (106.75 ± 25.275 cm^2) was recorded at $M^{100}NPK$ growth media. These points had the percentage leaf area increase from weeks 3 - 5 as follows: 25.14%, 13.40% and 12.16% for Control, $M^{25}NPK$ and $M^{100}NPK$ treatments, in that order. There was no significant difference ($P = 0.05$) amongst growth media from weeks 3 - 5.

Total leaf area of *T. occidentalis* grown in different growth media: The results of the total leaf area (cm^2) of *T. occidentalis* grown in different NPK growth media for 5 weeks are shown in Table 7. There was increase in the total leaf area from weeks 3 - 5 across growth media. The total leaf area value was higher in the Control medium compared to other growth media for weeks 3 - 5. There was rapid increase in the total leaf area value for all growth media. The percentage increase in total leaf area values for weeks 3 - 5 was 68.58%, 42.26%, 22.09%, 14.15%, 27.57%, 28.33% and 46.74% for Control, $M^{25}NPK$, $M^{50}NPK$, $M^{75}NPK$, $M^{100}NPK$, $M^{125}NPK$ and $M^{150}NPK$ media, respectively. At week 5, the Control medium (1492.04 ± 298.148 cm^2) had the highest total leaf area value, followed by $M^{25}NPK$ medium (1283.37 ± 762.582 cm^2) and it was significantly different ($P = 0.05$) from other growth media except $M^{25}NPK$ medium. The lowest mean value for total leaf area (650.58 ± 170.441 cm^2) was recorded at $M^{125}NPK$ medium.

Pigments composition of *T. occidentalis* leaves grown in different NPK growth media: The pigments composition of *T. occidentalis* leaves grown in different NPK growth media at 5 WAP are as shown in Table 8. The chlorophyll and carotenoid contents of *T. occidentalis* leaves varied and had significant

Table 7. Total leaf area (cm^2) of *T. occidentalis* in different NPK growth media.

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	885.08 ± 126.747^{a}	1084.72 ± 102.990^{a}	1492.04 ± 298.148^{a}	1153.9^{a}
M^{25}NPK	902.13 ± 344.894^{a}	998.57 ± 316.402^{a}	1283.37 ± 762.582^{ab}	1061.4^{a}
M^{50}NPK	761.71 ± 195.264^{ab}	843.38 ± 108.129^{ab}	929.94 ± 252.791^{bc}	845.0^{b}
M^{75}NPK	751.71 ± 251.736^{ab}	840.84 ± 246.707^{ab}	858.06 ± 332.972^{bc}	816.9^{b}
M^{100}NPK	617.72 ± 131.999^{ab}	747.35 ± 249.411^{ab}	788.01 ± 260.782^{bc}	717.7b^{c}
M^{125}NPK	506.96 ± 218.493^{b}	557.72 ± 250.009^{b}	650.58 ± 170.441^{c}	571.8^{c}
M^{150}NPK	523.32 ± 147.239^{b}	745.26 ± 208.057^{ab}	767.90 ± 204.799^{bc}	678.8^{bc}
Mean	706.94 ± 243.132^{b}	831.12 ± 256.815^{ab}	967.125 ± 438.675^{a}	
$LSD_{(P=0.05)}$	316.05	329.41	551.39	211.55

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

Table 8. Pigments composition (mg/g) of *T. occidentalis* leaves in different NPK growth media at 5 WAP.

Treatment	Chlorophyll *a*	Chlorophyll *b*	Total Chlorophyll	Carotenoid
Control	17.31 ± 0.191^{a}	15.90 ± 0.942^{a}	33.22 ± 1.131^{a}	2.82 ± 0.320^{c}
M^{25}NPK	9.66 ± 0.093^{b}	4.62 ± 0.743^{cd}	14.27 ± 0.650^{c}	6.00 ± 1.153^{a}
M^{50}NPK	15.68 ± 1.232^{a}	12.41 ± 1.181^{b}	28.08 ± 2.356^{b}	4.07 ± 0.720^{bc}
M^{75}NPK	9.44 ± 3.921^{b}	6.10 ± 2.633^{c}	15.54 ± 6.384^{c}	4.33 ± 0.551^{b}
M^{100}NPK	8.40 ± 2.623^{b}	4.52 ± 1.421^{cd}	12.92 ± 4.043^{c}	3.34 ± 0.415^{bc}
M^{125}NPK	17.15 ± 0.439^{a}	12.79 ± 0.792^{b}	29.94 ± 1.205^{ab}	3.24 ± 0.883^{bc}
M^{150}NPK	7.09 ± 0.395^{b}	3.65 ± 0.182^{d}	10.73 ± 0.457^{c}	3.21 ± 0.880^{bc}
$LSD_{(P=0.05)}$	3.0543	2.1370	4.9644	1.3419

Mean ± Standard deviation; Means with the same letter in a column are not significantly different; WAP = weeks after planting.

difference ($P \leq 0.05$) amongst growth media. Chlorophyll *a* content of the leaves was higher than chlorophyll *b* in all the growth media. The leaves grown in the Control medium had the highest chlorophyll content and were not significantly different from M^{125}NPK and M^{50}NPK media but these growth media differed significantly from others (M^{25}NPK, M^{75}NPK, M^{100}NPK, and M^{150}NPK). The lowest chlorophyll content of *T. occidentalis* leaves was recorded at M^{150}NPK growth medium. The chlorophyll *a*, chlorophyll *b* and total chlorophyll contents ranged from 7.09 - 17.31 mg/g, 3.65 - 15.90 mg/g and 10.73 - 33.22 mg/g, respectively. However, the result recorded for carotenoid of the leaves was different. The highest carotenoid content (6.00 mg/g) of the leaves was recorded at M^{25}NPK medium which was significantly different from other growth media

while the least carotenoid content (2.82 mg/g) was obtained at the Control medium. The carotenoid contents recorded were lower than the chlorophyll contents.

Root length (cm) of *T. occidentalis* grown in different growth media at 5 WAP: The root length of *T. occidentalis* grown in different growth media (Figure 1). The root length varied in different NPK growth media. The root lengths ranged from 13.18 - 20.55 cm. *T. occidentalis* grown in Control medium had the highest root length compared to other growth media, which was significantly different at $P = 0.05$. For the NPK growth media, the root length values differed from one another but there was no significant difference at $P = 0.05$. However, the lowest root length was recorded at M^{75}NPK growth media. From Figure 1, the treatment (bar) that has "a" is significantly different ($p \leq 0.05$) compared with other treatments (bars) having "b" while the bars having the same alphabet are not significantly different at $p \leq 0.05$.

Root fresh weight (g) of *T. occidentalis* grown in different growth media at 5 WAP: The fresh weight of *T. occidentalis* roots varied in the NPK growth media (Figure 2). The root fresh weight values ranged from 2.02 - 8.77 g. The root fresh weight values recorded for NPK growth media were statistically different ($P = 0.05$) with the Control medium. Among the growth media, the Control medium had the highest (8.77 g) root fresh weight while the lowest value (2.02 g) was recorded at M^{125}NPK medium.

Root dry weight (g) of *T. occidentalis* grown in different growth media at 5 WAP: The root dry weight of *T. occidentalis* decreased as the quantity of NPK increased in the growth media (Figure 3). Among the growth media, the Control medium had the highest root dry weight (0.71 g) and was significantly different when compared to other growth media. Although the root dry weight values differed and ranged from 0.24 - 0.38 g (M^{150}NPK to M^{25}NPK medium), there was no significant difference in NPK growth media.

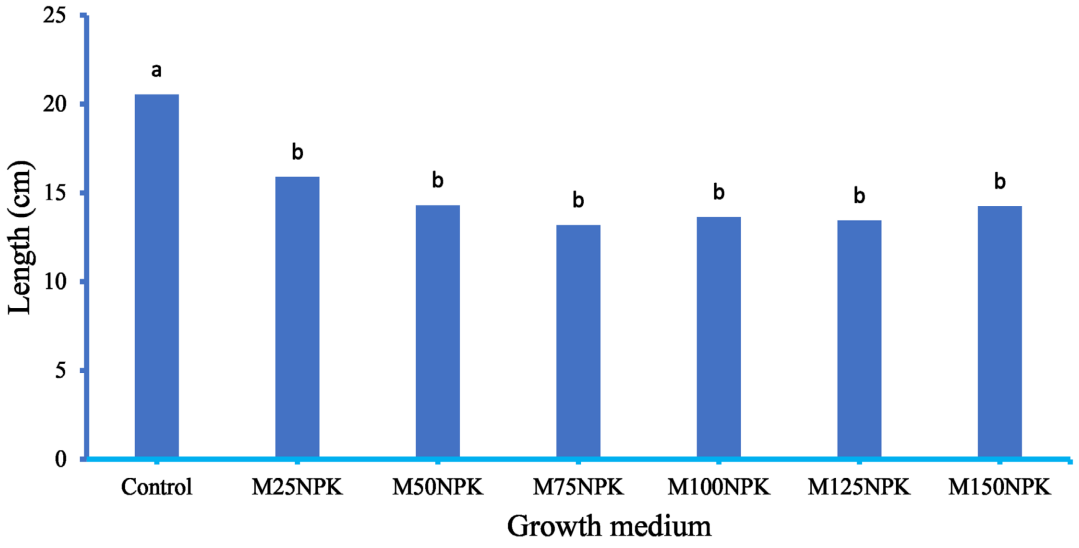

Figure 1. Root length of *T. occidentalis* grown in different NPK growth media at 5 WAP.

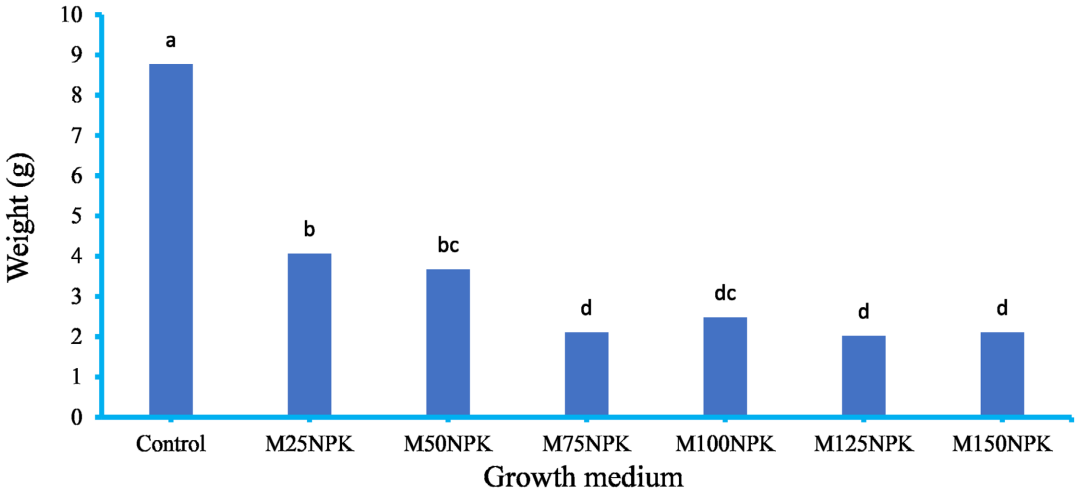

Figure 2. Root fresh weight of *T. occidentalis* grown in different NPK growth media at 5 WAP.

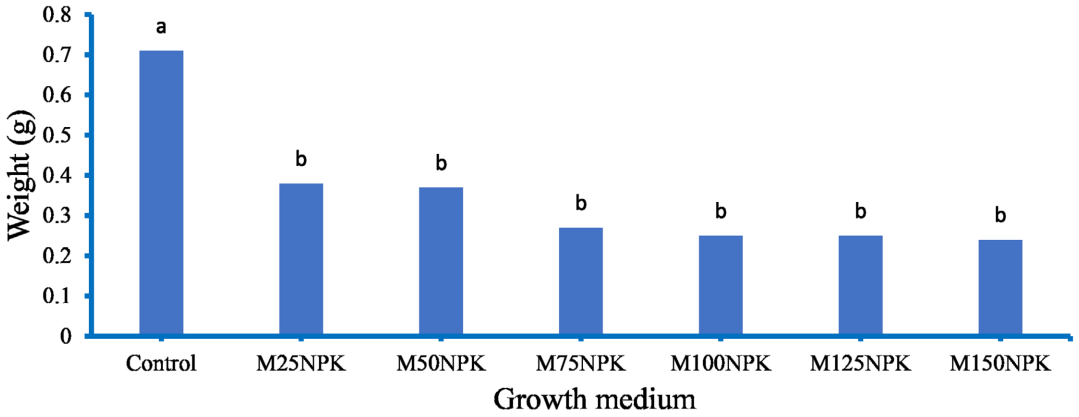

Figure 3. Root dry weight of *T. occidentalis* grown in different NPK growth media at 5 WAP.

4. Discussion

Growth of *T. occidentalis* grown in different growth media

The vine lengths and number of leaves of *T. occidentalis* recorded in this study were lower compared to works of other researchers [18]-[23]. Ndor and Dauda [18] reported the vine length range of 51.22 - 79.23 cm and number of leaves range 18.53 - 27.46 for 4 - 6 weeks after germination of *T. occidentalis* while Chukwudi and Agbo [19] reported 40.60 - 220.50 cm and 14.80 - 97.20 ranges, respectively, 3 - 9 weeks after transplanting. This variation could as a result of trellis. Trellis improved the vine length of cucumber and fluted pumpkin over the unstaked [19] [24]. They suggested that the leaves on the staked plants were all exposed to greater light interception leading to a higher accumulation of photosynthates for vegetative growth. According to Akpaniwo *et al.* [20], the vine length of untreated *T. occidentalis* was 146 cm while irradiated *T. occidentalis* with 100 kv reduces vine length to 116 cm. Vine length is a major leave yield component of fluted pumpkin. Also, Akpaniwo *et al.* [20] suggested higher number of leaves per plant with longer vine length yield. Oke [21] documented that *T. occidentalis* grown for 3 - 12 weeks after planting had the following

growth indices range: vine length (189.61 - 225.17 cm); number of leaves (13.61 - 40.05); vine girth (0.86 - 0.99 cm); leaf area (118.14 - 370.06 cm^2); total leaf area (1607.87 - 14820.90 cm^2). The stem girth in this study was lower compared to the stem girth range of 5.13 - 9.4 mm as reported by Chukwudi and Agbo [19]. This difference could as a result of frequent leaf cutting of *T. occidentalis* which provides opportunity for more growth.

Nwonuala and Obiefuna [22] recorded varied growth indices range of different genotype of *T. occidentalis* at 6WAP: vine length (81.3 - 158.3 cm); number of leaves (58.3 - 93.5); leaf area (31.8 - 79.0 cm^2); internode (5.4 - 7.7 cm) and petiole length (5.5 - 7.6 cm) while Uwalaka *et al.* [21] reported: main vein length (113.24 to 128.65 cm), and stem girth (0.32 to 0.37 cm) range from 6 - 8WAP and number of leaves (8.24 - 26.73) from 2 - 8 WAP. There is the difference among several researchers and these differences in the growth indices could be attributed to genetic differences according to Chukwudi and Agbo [25]. It is also possible that the ecological system will also affect the growth parameters giving rise to varied results. According to Smith and Ayeigbara [26], the quicker release of N, P, and K from high nitrogen fertilizer will make for quick growth but weaker plants that are susceptible to attacks by diseases and pests. The availability of nutrients in the ecosystem will directly or indirectly culminate in the level of photosynthetic pigments present in *T. occidentalis.* Earlier, Noggle and Fritz [27] documented that dry matter accumulation is a result of nutrient uptake and it is one of the measures of plant growth. According to Ibeawuchi [28], dry matter accumulation reflects the relative growth rate as regards to the net assimilation rate.

5. Conclusion

From the results recorded, the average pH value and sulphate content of the solutions reduced slightly while the electrical conductivity increased after 28 days. The proportion of the minerals varied in the hydroponic solutions. Considering the performance of *T. occidentalis* grown in different NPK, the Control treatment had the highest vine main length, number of leaves, leaf area, total leaf area, petiole length, and pigment composition of *T. occidentalis* compared to other treatments. However, among the NPK treatments, M^{25}NPK treatment effectively enhanced some of the growth indices such as vine main length, number of leaves, leaf area, total leaf area, carotenoid content, root length, root fresh weight, and root dry weight. The use of NPK fertilizer in the cultivation of vegetables especially fluted pumpkins in a non-circulatory hydroponic system should be encouraged.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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