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PERFORMANCE OF TELFAIRIA OCCIDENTALIS LEAF GROWN IN UREA HYDROPONIC SOLUTION

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ABSTRACT

The study evaluated the performances of Telfairia occidentalis Hooker fil. under varying growth media subject to the amount of Urea granules (25 g, 50 g, 75 g, 100 g, 125 g and 150 g) dissolved in water containing micronutrients. The growth media were M25U, M50U, M75U, M100U, M125U, M150U, and Control. Two-week old seedlings of T. occidentalis raised using River-sand were transferred into the non-circulatory growth media. 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 following standard procedures. Across the growth media studied, the Control medium had the highest VML, NL, LA, TLA, PL and pigment composition of T. occidentalis. However, among the Urea growth media, M25U medium produced relatively the highest VML, NL, TLA, total chlorophyll, and RFW of T. occidentalis while M50U medium had the highest LA, RL and RDW. Also, T. occidentalis leaves grown in the Control medium had the highest chlorophyll content (33.22 mg/g), followed by M25U medium (22.88 mg/g) and was significantly different from the other growth media.M100U medium effectively enhanced carotenoids content (6.49 mg/g) of T. occidentalis compared to others. The study showed that the mineral composition of the growth media enhanced the performance of T. occidentalis. Hence, M25U growth media are recommended for growing T. occidentalis.

INTRODUCTION

Plants do not necessarily need soil in order to grow and survive. According to White and Brown (2010), plants obtain their inorganic elements from the soil solution. Soil serves as a medium to support plant and to retain nutrients for plants' utilization. Hence, any medium that is stable enough to support plant and retain nutrients can do the same job as soil without being restricted to the ground. Hydroponic is the cultivation of plants, edible and ornamental, in water containing dissolved nutrients. Growing fresh produce in soilless systems could be a possible solution to food insecurity issues regardless of soil quality, climate or space (Resh & Howard, 2012). According to Santos and Ocampo (2005), hydroponics provides an instant and also long-term remedy to the difficult of inability of a household to produce its own vegetables under urban settings. A hydroponic system allows for uninterrupted vegetable production no matter the period (Santos & Ocampo, 2009). It is one of the technologies used in places not appropriate for traditional farming systems (Pelesco & Bentor-Jr., 2013). This helps to mitigate the difficulty of climate change, assist in production system management for efficient exploitation of natural resources and alleviation of malnutrition (Butler & Oebker, 2006). The use of controlled environments can overcome cultivation difficulties and could be a way to manipulate phenotypic variation in bioactive compounds (Murali-Mugundhan et al., 2011).

It has been claimed that the key to successful hydroponics culture is the nutrient solution (Hedio, 2000). To achieve optimized growing systems, different types of crops, nutrient solutions, lighting and other factors are important when determining the crops that will be successful in hydroponic systems from environmental, economic and nutritional perspectives (Treftz & Omaye, 2015). Previous literature has focused on various hypotheses of growing cucumbers, tomatoes, carrots, peppers and strawberries hydroponically (Arias et al., 2000; Parađiković et al., 2011; Coolong, 2012).

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According to Hickman (2011), the main greenhouse crops (including soil and soilless production) are tomato, cucumber, sweet pepper, herbs, eggplant and strawberry, in that sequence. Resh (1995), earlier reported that the major vegetables grown in soilless cultivation are tomato, cucumber, sweet pepper and L. sativa in that order. But in Latin America, the main vegetables include; L. sativa, arugula, tomato, sweet pepper, cucumber and strawberry (Rodriguez-Delfin, 2012) in that same order. With the hydroponic technology being used more frequently, it has become imperative to assess which crops are suitable to be grown in hydroponic systems. The production of vegetable crops and ornamentals using different soilless culture techniques has been practiced and commercialized (Kratky et al., 1988; Pelesco & Bentor-Jr., 2013).

However, hydroponic as a way of growing plants is rarely practiced in Nigeria even though the technology had long existed in the industrialized nations. Hydroponics as a means of growing plants should be embraced in unindustrialized nations like Nigeria. The ability to formulate nutrients locally to grow plants should be of priority to researchers. The cost of producing plants will reduce tremendously if required materials are sourced locally and are affordable to farmers. However, this study is aimed at using urea fertilizer in the formulation of locally hydroponic nutrient solutions for growing T. occidentalis and evaluate how the solutions affects its performance.

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 (4º54′0″N 6º54′0″E) while the urea 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 (2002) was used with modification in nutrient formulation and container used. Urea 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 a space for aeration with the addition of 20 ml micronutrients stock solution (0.6 g H_3BO_3; 0.4 g $MnCl_2.4H_2O$; 0.05 g $ZnSO_4$; 0.5 g $CuSO_4.5H_2O$; 0.02 g $Na_2MoO_4.2H_2O$) and Epsom salt (9.8 g MgSO4). The Control medium (water) was setup without the addition of Urea, micronutrients and Epsom salt. These formulations were replicated four times. The growth media were designated as: $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$, $M^{150}U$, and Control (0 g Urea) depending on the amount urea dissolved in water.

Study Site and Weather Condition

The study was conducted in a screen house inside the University of Port Harcourt (Lat. N4º54'15", Long. E6º54'35"). The site was free from direct rainfall and was open to sunlight anytime of the day. The screen house had a transparent cover that permits light penetration and hinders direct rainfall. During the period of experiment, the weather condition of the University was relatively wet with daytime temperature that ranges from 24ºC in early morning to 32ºC 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 (1993). 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 (2002) while the carotenoid content was determined following the method of Sumanta et al. (2014).

Statistical Analysis

The data obtained for the morphological characters and pigment contents of fluted pumpkin were subjected to statistical analysis.

RESULTS

Vine Main Length of *T. occidentalis* Grown in Different Growth Media

The growth performance of *T. occidentalis* in varying Urea solutions with respect to vine main length (VML) are presented in Table 1. The rate at which the VML value for Control treatment increased (28.63 – 57.05 cm) after week 4 was faster when compared to other growth media. This was followed by $M^{25}U$ growth medium (27.98 – 37.23 cm). The percentage increase in VML values were 99.27%, 33.06%, 33.87%, 2.66%, 0.55%, 4.12% and 0.23% for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ growth media, respectively. The result of increasing the Urea concentration in the medium did not produce an increased VML. At 5 Weeks after planting, the lowest VML (21.95 ± 4.944 cm) was obtained at $M^{150}U$ medium and the VML value for Control medium was significantly different from other media.

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

Treatment	Duration			Mean	Percentage Increase (4 – 5 WAP)
	3 WAP	4 WAP	5 WAP		
Control	23.23 ± 5.752[a]	28.63 ± 10.036[a]	57.05 ± 18.018[a]	36.300[a]	99.27
$M^{25}U$	22.55 ± 3.594[a]	27.98 ± 7.083[a]	37.23 ± 12.831[b]	29.250[ab]	33.06
$M^{50}U$	17.10 ± 6.434[a]	18.60 ± 4.614[a]	24.90 ± 7.099[b]	20.200[c]	33.87
$M^{75}U$	23.15 ± 5.501[a]	30.13 ± 13.818[a]	30.93 ± 14.695[b]	28.067[bc]	2.66
$M^{100}U$	25.58 ± 3.007[a]	27.50 ± 2.783[a]	27.65 ± 3.226[b]	26.908[bc]	0.55
$M^{125}U$	23.93 ± 6.777[a]	26.73 ± 9.554[a]	27.83 ± 10.169[b]	26.158[bc]	4.12
$M^{150}U$	21.23 ± 4.307[a]	21.90 ± 4.917[a]	21.95 ± 4.944[b]	21.692[bc]	0.23
Mean	22.393 ± 5.257[b]	25.921 ± 8.3164[b]	32.504 ± 14.9683[a]		
$LSD_{(P=0.05)}$	7.6847	12.257	16.617	8.0275	

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

Stem Girth of *T. occidentalis* Grown in Different Growth Media

The stem girth of *T. occidentalis* grown in different concentration of Urea solutions is shown in Table 2. There was no exponential growth in the stem girth in all the growth media. The stem girth from week 3 – 5 for the growth media ranged thus: Control (4.55 – 5.35 mm), $M^{25}U$ (4.68 – 4.88 mm), $M^{50}U$ (4.73 – 5.33 mm), $M^{75}U$ (3.83 – 4.60 mm), $M^{100}U$ (3.93 – 5.83 mm), $M^{125}U$ (3.93 – 4.43 mm) and $M^{150}U$ (2.73 – 4.98 mm). Amongst growth media, the percentage increase in stem girth was 17.58%, 4.27%, 12.68%, 20.10%, 48.35%, 12.72% and 82.42% for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ growth media, respectively. $M^{150}U$ medium had the highest percentage increase of stem girth from week 3 – 5. However, at week 5, the highest value for stem girth (5.83 ± 0.670 mm) was recorded at $M^{100}U$ growth medium while the lowest (4.43 ± 0.670 mm) at $M^{125}U$ growth medium. These values were statistically different at $P = 0.05$. Considering the mean growth rate of the stem girth from 3 – 5 WAP, $M^{50}U$ growth medium had the stem girth of *T. occidentalis*, followed by Control, $M^{25}U$, $M^{100}U$, $M^{75}U$, $M^{125}U$ and $M^{150}U$, in that order. The mean stem girth value for $M^{50}U$ was significantly different from $M^{75}U$, $M^{125}U$ and $M^{150}U$, respectively.

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

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	4.55 ± 0.635[a]	4.65 ± 0.785[a]	5.35 ± 0.370[ab]	4.8500[ab]
$M^{25}U$	4.68 ± 0.754[a]	4.70 ± 1.344[a]	4.88 ± 1.330[ab]	4.7500[ab]
$M^{50}U$	4.73 ± 1.609[a]	5.28 ± 1.287[a]	5.33 ± 1.253[ab]	5.1083[a]
$M^{75}U$	3.83 ± 0.888[ab]	3.88 ± 0.939[ab]	4.60 ± 0.821[ab]	4.1000[bc]
$M^{100}U$	3.93 ± 0.613[ab]	3.93 ± 0.613[ab]	5.83 ± 0.670[a]	4.5583[ab]
$M^{125}U$	3.93 ± 1.307[ab]	3.93 ± 1.307[ab]	4.43 ± 0.670[b]	4.0917[bc]
$M^{150}U$	2.73 ± 0.858[b]	2.73 ± 0.858[b]	4.98 ± 0.411[ab]	3.4750[c]
Mean	4.0543 ± 1.184[b]	4.1536 ± 1.2088[b]	5.0534 ± 0.9094[a]	
$LSD_{(P=0.05)}$	1.4605	1.5505	1.3014	0.8684

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

Number of Leaves of *T. occidentalis* Grown in Different Growth Media

The number of leaves grown in different concentrations of Urea growth media are presented in Table 3. Increased quantity of Urea did not record a definite pattern in terms of size (either increase or decrease) in the number of leaves of *T. occidentalis*. The percentage increase in the number of leaves from weeks 3 – 5 was: 34.38%, 30.00%, 13.04%, 24.14%, 12.12%, 10.71% and 3.13%, respectively for the Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ media. Control medium had the highest percentage increase for number of leaves of *T. occidentalis* from week 3 – 5, followed by $M^{25}U$ growth medium. Hence, the highest mean value for number of leaves (10.75 ± 0.957) was recorded at the Control medium while the lowest (6.50 ± 1.915) was recorded at $M^{50}U$ medium at week 5.

Table 3. Number of leaves of *T. occidentalis* in different Urea 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]
$M^{25}U$	7.50 ± 0.577[ab]	8.75 ± 1.708[a]	9.75 ± 2.062[ab]	8.6667[a]
$M^{50}U$	5.75 ± 2.754[b]	6.00 ± 2.449[b]	6.50 ± 1.915[c]	6.0833[c]
$M^{75}U$	7.25 ± 1.258[ab]	8.50 ± 1.000[ab]	9.00 ± 0.816[ab]	8.2500[ab]
$M^{100}U$	8.25 ± 0.957[a]	9.25 ± 0.957[a]	9.25 ± 0.957[ab]	8.9167[a]
$M^{125}U$	7.00 ± 1.414[ab]	7.75 ± 1.893[ab]	7.75 ± 1.893[bc]	7.5000[b]
$M^{150}U$	8.00 ± 1.633[a]	8.00 ± 1.633[ab]	8.25 ± 1.258[bc]	8.0833[ab]
Mean	7.3929 ± 1.5477[b]	8.1429 ± 1.7152[ab]	8.7500 ± 1.8584[a]	
$LSD_{(P=0.05)}$	2.2058	2.3140	2.1941	1.1475

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

Leaf Petiole Length of *T. occidentalis* Grown in Different Growth Media

The leaf petiole length (LPL) of *T. occidentalis* grown in varying concentrations of Urea growth media varied across treatments (Table 4). The rate at which the petiole lengths increased were not significant at $p \leq 0.05$ across and within growth media from weeks 3 – 5. The ranges within growth media were: Control (3.90 – 4.90 cm), $M^{25}U$ (4.10 – 4.38 cm), $M^{50}U$ (4.03 – 4.95 cm), $M^{75}U$ (4.20 – 4.98 cm), $M^{100}U$ (4.30 – 4.85 cm), $M^{125}U$ (4.33 – 4.45 cm) and $M^{150}U$ (4.33 – 5.25 cm). Amongst growth media, the percentage increase in the petiole lengths was 25.64%, 6.83%, 22.83%, 18.57%, 12.79%, 2.77% and 21.25% for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ treatments, respectively. Control medium had the highest percentage increase of LPL from weeks 3 – 5. However, at week 5, the highest mean value for LPL (5.25 ± 1.611 cm) was recorded at $M^{150}U$ medium while the lowest (4.38 ± 0.479 cm) at $M^{25}U$ medium. There was no significant difference among growth media.

Table 4. Petiole length (cm) of *T. occidentalis* leaves in different Urea 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
$M^{25}U$	4.10 ± 0.577^a	4.20 ± 0.589^a	4.38 ± 0.479^a	4.2250^a
$M^{50}U$	4.03 ± 1.343^a	4.88 ± 1.758^a	4.95 ± 1.771^a	4.6167^a
$M^{75}U$	4.20 ± 0.712^a	4.25 ± 0.742^a	4.98 ± 1.150^a	4.4750^a
$M^{100}U$	4.30 ± 0.503^a	4.33 ± 0.472^a	4.85 ± 0.719^a	4.4917^a
$M^{125}U$	4.33 ± 0.914^a	4.45 ± 1.248^a	4.45 ± 1.248^a	4.4083^a
$M^{150}U$	4.33 ± 1.584^a	4.33 ± 1.584^a	5.25 ± 1.611^a	4.6333^a
Mean	4.3107 ± 0.8842^a	4.3750 ± 1.0473^a	4.6786 ± 1.1622^a	
$LSD_{(P=0.05)}$	1.4047	1.7059	1.7980	1.569

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

Leaf Internodes of *T. occidentalis* Grown in Different Growth Media

The growth performance of *T. occidentalis* in varying Urea solutions with respect to leaf internodes are presented in Table 5. 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 growth media for weeks 3 – 5 after seedlings were transferred into the growth media. The percentage increase in leaf internodes values was 4.09%, 16.23%, 11.54%, 23.77%, 13.65%, 4.48% and 6.00% for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ growth media, respectively. The effect of increasing the Urea concentration in the medium did not record a definite pattern in terms of leaf internodes. The least value of leaf internodes (2.90 ± 1.023 cm) was recorded at $M^{50}U$.

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

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	4.40 ± 1.444^a	4.50 ± 2.380^a	4.58 ± 0.419^a	4.4917^a
$M^{25}U$	3.08 ± 0.435^b	3.15 ± 0.465^{ab}	3.58 ± 1.014^a	3.2667^b
$M^{50}U$	2.60 ± 0.542^b	2.80 ± 1.023^b	2.90 ± 1.023^a	2.7667^b
$M^{75}U$	3.23 ± 1.452^b	3.30 ± 1.402^{ab}	4.03 ± 1.297^a	3.5167^b
$M^{100}U$	2.93 ± 0.737^b	2.95 ± 0.695^b	3.33 ± 0.427^a	3.0667^b
$M^{125}U$	3.35 ± 0.473^b	3.50 ± 0.959^{ab}	3.50 ± 0.959^a	3.4500^b
$M^{150}U$	2.83 ± 0.330^b	2.83 ± 0.330^b	3.00 ± 1.042^a	2.8833^b
Mean	3.203 ± 0.8805^a	3.290 ± 1.0175^a	3.560 ± 1.2542^a	
$LSD_{(P=0.05)}$	1.0608	1.4525	1.8941	0.7858

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

Leaf Area of *T. occidentalis* Grown in Different Growth Media

Table 6 shows the leaf area of *T. occidentalis* grown in different Urea growth media. There was an increase in the leaf area from weeks 3 – 5 and the growth performance varied across the growth media. The leaf area ranged from 110.28 – 138.00 cm^2, 105.39 – 117.57 cm^2, 135.59 – 147.29 cm^2, 93.73 – 98.10 cm^2, 86.93 – 89.93 cm^2, 95.54 – 111.85 cm^2, and 94.56 – 100.26 cm^2 for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ growth media, respectively. The $M^{50}U$ medium had the highest leaf area value (147.29 ± 59.395 cm^2) at week 5, followed by Control medium (138.00 ± 17.617 cm^2) while the lowest value (89.93 ± 29.796 cm^2) was recorded at $M^{100}U$ medium. These highest and lowest points had the percentage leaf area increase from weeks 3 – 5 as follows: 25.14%, 8.63% and 3.45% for Control, $M^{50}U$ and $M^{100}U$ media, respectively. However, there was no significant difference ($P = 0.05$) amongst growth media from weeks 4 – 5.

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

Treatment	Duration			Mean
	3 WAP	4 WAP	5 WAP	
Control	110.28 ± 5.576^{ab}	124.39 ± 14.924^a	138.00 ± 17.617^a	124.22^{ab}
$M^{25}U$	105.39 ± 44.783^{ab}	116.28 ± 32.724^a	117.57 ± 33.129^a	113.08^{bc}
$M^{50}U$	135.59 ± 48.126^a	143.36 ± 59.317^a	147.29 ± 59.395^a	142.08^a
$M^{75}U$	93.73 ± 8.203^{ab}	95.88 ± 19.324^a	98.098 ± 17.588^a	95.90^c

$M^{100}U$	86.93 ± 32.688^{b}	89.93 ± 29.796^{a}	89.93 ± 29.796^{a}	92.26^{c}
$M^{125}U$	95.54 ± 27.507^{ab}	111.85 ± 37.758^{a}	111.85 ± 37.758^{a}	106.42^{bc}
$M^{150}U$	94.558 ± 6.870^{ab}	100.26 ± 30.741^{a}	100.26 ± 30.741^{a}	101.69^{bc}
Mean	103.145 ± 29.792^{a}	111.706 ± 36.223^{a}	114.711 ± 36.367^{a}	
$LSD_{(P=0.05)}$	43.451	52.077	51.795	26.303

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

Total Leaf Area of *T. occidentalis* Grown in Different Growth Media

The total leaf area of *T. occidentalis* grown in different Urea growth media for 5 weeks is 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 and it was significantly different ($P = 0.05$) from other growth media except $M^{25}U$ medium. There was rapid increase in the total leaf area value for all growth media. The percentage increase from weeks 3 – 5 for total leaf area values was 68.58%, 41.98%, 26.51%, 31.68%, 5.74%, 31.52% and 9.26% for Control, $M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$ and $M^{150}U$ growth media, respectively. At week 5, the Control medium (1492.04 ± 298.148 cm^2) had the highest total leaf area value, followed by $M^{25}U$ medium (1119.77 ± 286.000 cm^2). The lowest mean value for total leaf area (821.40 ± 253.916 cm^2) was recorded at $M^{100}U$ medium.

Table 7. Total leaf area (cm^2) of *T. occidentalis* in different Urea 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}
$M^{25}U$	788.69 ± 356.772^{a}	1000.77 ± 273.130^{a}	1119.77 ± 286.000^{ab}	969.7^{ab}
$M^{50}U$	690.22 ± 134.854^{a}	751.36 ± 90.560^{a}	873.17 ± 131.333^{b}	771.6^{b}
$M^{75}U$	677.54 ± 117.140^{a}	823.05 ± 236.101^{a}	892.19 ± 225.461^{b}	797.6^{b}
$M^{100}U$	776.81 ± 177.727^{a}	821.40 ± 253.916^{a}	821.40 ± 253.916^{b}	806.5^{b}
$M^{125}U$	692.83 ± 305.588^{a}	911.22 ± 464.163^{a}	911.22 ± 464.163^{b}	838.4^{b}
$M^{150}U$	785.33 ± 222.153^{a}	785.33 ± 222.153^{a}	858.06 ± 96.061^{b}	809.6^{b}
Mean	756.636 ± 209.2924^{b}	882.55 ± 257.7472^{ab}	995.4064 ± 331.0746^{a}	
$LSD_{(P=0.05)}$	328.62	384.44	403.83	215.47

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

Pigments Composition of *T. occidentalis* Leaves Grown in Different Urea Growth Media

The pigments composition of *T. occidentalis* leaves grown in different Urea growth media at 5 WAP are as shown in Table 8. The chlorophyll and carotenoid contents of the leaves varied and were significantly different ($P \leq 0.05$) amongst growth media. Chlorophyll *a* content of the leaves was higher than chlorophyll *b* in all the growth media. *Telfairia occidentalis* leaves grown in the Control medium had the highest chlorophyll content and was significantly different from the other growth media. The lowest chlorophyll content of the leaves was recorded at $M^{150}U$ medium. The chlorophyll *a*, chlorophyll *b* and total chlorophyll contents ranged from 2.50 – 17.31 mg/g, 1.13 – 15.90 mg/g and 3.63 – 33.22 mg/g, respectively. However, the result obtained for carotenoid of the leaves was different. The highest carotenoid content (6.49 mg/g) of the leaves was recorded at $M^{100}U$ medium which was significantly different from other growth media while the lowest carotenoid content (0.45 mg/g) was recorded at $M^{25}U$ medium. The carotenoid contents were lower compared to the chlorophyll *a* content.

Table 8. Pigments composition (mg/g) of *T. occidentalis* leaves in different Urea 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^{dc}
$M^{25}U$	14.81 ± 1.142^{b}	8.07 ± 0.243^{b}	22.88 ± 1.357^{b}	0.45 ± 0.125^{e}
$M^{50}U$	13.45 ± 1.218^{b}	8.25 ± 1.534^{b}	21.70 ± 2.700^{b}	4.53 ± 0.375^{b}
$M^{75}U$	4.39 ± 0.292^{d}	2.35 ± 0.389^{c}	6.74 ± 0.681^{c}	3.63 ± 0.286^{bc}
$M^{100}U$	10.78 ± 3.241^{c}	7.94 ± 2.831^{b}	18.72 ± 5.969^{b}	6.49 ± 2.215^{a}
$M^{125}U$	3.94 ± 1.578^{d}	2.451 ± 1.021^{c}	6.393 ± 2.387^{c}	3.78 ± 0.878^{bc}
$M^{150}U$	2.50 ± 0.295^{d}	1.13 ± 0.254^{c}	3.63 ± 0.533^{c}	1.713 ± 0.460^{de}
$LSD_{(P=0.05)}$	2.4185	2.1463	4.3792	1.5723

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

Root Length, Root Fresh Weight and Root Dry Weight of *T. occidentalis* Grown in Different Growth Media at 5 WAP

The root length also varied in different Urea growth media (Figure 1). The root lengths ranged from 15.08 – 24.20 cm and the values recorded fluctuate across growth media. *Telfairia occidentalis* grown in $M^{50}U$ medium had the highest root length (24.20 cm) compared to other media, which was not significantly different at $p = 0.05$ while the lowest was recorded at $M^{150}U$ growth media.

The root fresh weight decreased as the quantity of Urea increased in the growth media (Figure 2). The root fresh weight values of *T. occidentalis* ranged from 2.24 – 8.77 g. The root fresh weight values recorded for Urea growth medium 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 (2.24 g) was recorded at $M^{150}U$ medium.

The root dry weight values of *T. occidentalis* varied across the Urea growth media and ranged from 0.17 – 0.71 g (Figure 3). Among the growth media, the Control medium had the highest root dry weight (0.71 g) while the lowest value (0.17 g) was recorded at $M^{125}U$ medium. There was significant difference in the value recorded for Control medium and other growth media.

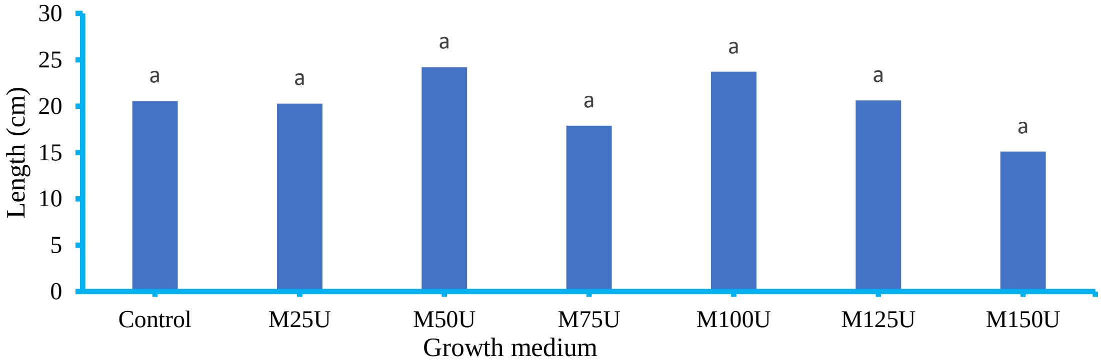

Figure 1. Root length of *T. occidentalis* grown in different Urea growth media at 5 WAP

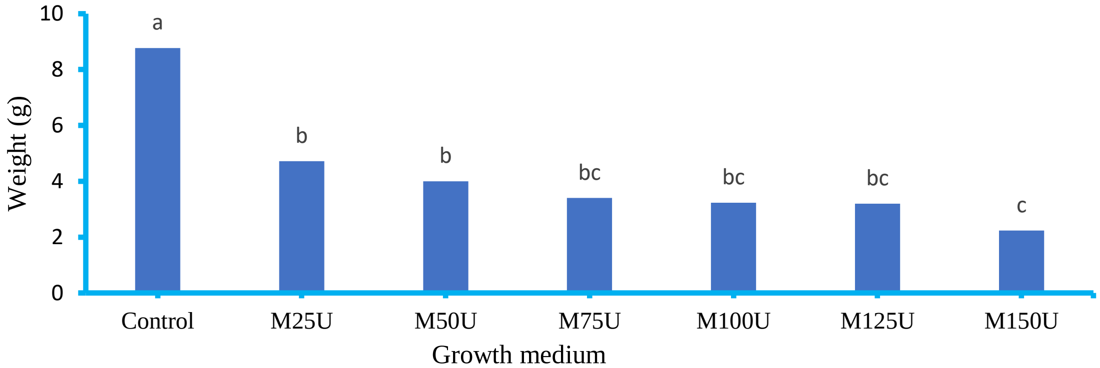

Figure 2. Root fresh weight of *T. occidentalis* grown in different Urea growth media at 5 WAP.

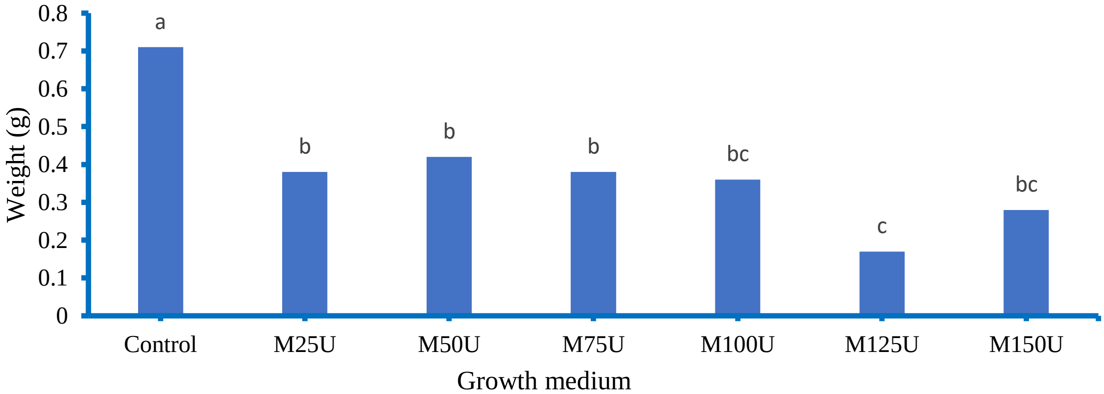

Figure 3. Root dry weight of *T. occidentalis* grown in different Urea growth media at 5 WAP

DISCUSSIONS

The performance of *T. occiddentalis* varied across Urea growth media ($M^{25}U$, $M^{50}U$, $M^{75}U$, $M^{100}U$, $M^{125}U$, $M^{150}U$).$M^{25}U$ medium effectively enhanced VML, NL, LA, TLA, carotenoids content, RL, RFW and RDW. This suggest that lower quantity of macronutrients in hydroponic solution will improve the performance of *T. occidentalis.* The values obtained from the results for number of leaves, leaf area per leaf and total plant leaf area of *T. occidentalis* were in conformity with the work of Oke (2015), who reported 13.61, 118.1 cm^2 and 1607.87 cm^2 at 3 WAP for number of leaves, leaf area and total plant leaf area, respectively. This also agreed with works of Akanbi et al. (2000), Shiyam and Binang (2013) and Usman (2015). Ndor et al. (2012) reported the number of leaves of fluted pumpkin grown in sawdust, River sand and topsoil as 9.33, 9.00 and 8.33 respectively at two (2) weeks after sowing. However, the average values for number of leaves and leaf area per leaf of *T. occidentalis* at 6 WAP reported by Nwonuala and Obiefuna (2015) varied significantly from this present work. This difference probably occurred due to the mineral nutrition supplied to the plant. Although, nutrient availability is crucial in the photosynthetic capacity of a crop, it is worthy to note that the number of leaves and the surface area of leaves affect directly or indirectly the photosynthetic rate of crops. Vegetable consumers depend majorly on the leaves of fluted pumpkin in the preparation of food and its leaves extract for medicinal purposes. This underscores the need to grow more leaves.

The *T. occidentalis* vine main lengths obtained in different Urea treatments were lower than those reported by other researchers (Nwonuala & Obiefuna, 2015; Oke, 2015) on the same plant. They reported average vine main length of 158.30 cm and 189.61 cm at 6 WAP and 3 WAP, respectively. Similarly, the highest stem girth obtained from the treatments was 0.58 cm, which was also lower compared to the works of Ndor et al. (2012) and Oke (2015). Ndor et al. (2012) reported stem girth of *T. occidentalis* grown in sawdust (1.98 cm), river sand (2.10 cm) and topsoil (1.87 cm) at 2 WAP, while Oke (2015) recorded stem girth of 0.86 cm on the same plant at 3 WAP. The variation in the stem girth by several researchers could be as a result of different treatments given to *T. occidentalis.* This presupposes that the performance of *T. occidentalis* is dependent on treatment and growth medium.

The leaf petiole length and internode length of *T. occidentalis* grown in different solutions of Urea were comparable with the values reported by Nwonuala and Obiefuna (2015), who worked on the yield and yield component of fluted pumpkin landrace. The root lengths of *T. occidentalis* grown in varying proportion of Urea in solution were significantly higher than the values reported by Ndor et al. (2012), who worked on growth of fluted pumpkin in different solid media. They observed and recorded the root length of *T. occidentalis* in different media as follows: sawdust (11.68 cm), River sand (11.12 cm) and topsoil (10.12 cm). This observation suggests that the compact nature of the growth medium used in growing *T. occidentalis* affects the root length. The roots of *T. occidentalis* grown in solution were soft and tender when compared to the texture of roots grown in other solid media (such as topsoil, River sand and sawdust).

The total chlorophyll content of *T. occidentalis* were higher than the carotenoid content. Total chlorophyll content of *T. occidentalis* grown in different Urea solutions were higher compared to other vegetables (such as Chinese Cabbage, *L. sativa*, Broccoli, Cauliflower, Brussel's sprout and red Cabbage) as reported by Pandey et al. (2015). They reported the total chlorophyll range of 2.23 – 16.92 mg/g. Chlorophylls are crucial components for photosynthesis (Pandey et al., 2015). According to Mustapha and Babura (2009), carotenoids comprise a large group of natural pigments widely distributed in the plant and animal kingdoms. They are yellow-orange in colour, insoluble in water but soluble in organic solvents. They are present as pigments in many vegetables and fruits and are associated with chlorophyll in higher plants, playing important role during photosynthesis by passing on the light energy they absorb to chlorophyll, they also protect the chlorophyll from excess light and oxidation. This function accounts for the low value obtained for carotenoids when compared to chlorophyll content of *T. occidentalis* in different growth media used.

CONCLUSIONS

Considering the performance of *T. occidentals* grown in different Urea solutions, 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 Urea treatments, $M^{25}U$ effectively enhanced some of the growth indices such as vine main length, number of leaves, leaf area, total leaf area, total chlorophyll, and root fresh weight of *T. occidentalis* while $M^{50}U$ treatment had the highest leaf area, root length and root dry weight. The study has shown that appropriate proportion of Urea in solution can be used to grow *T. occidentalis.* Therefore, pre-mixed fertilizers for growing vegetables should be developed to reduce the technicality involved for the ordinary farmers, who form the larger part of the pyramid in crop production.

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