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Effects of Elevated Ambient Temperature on Telfairia Occidentallis was Mitigated by Conservative Agriculture: A Demonstration of Global Warming and Adaptation Measures

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Abstract
Global warming has recently attracted both local and global attention because it has potential adverse effects on the environment, human health and food security. To better understand the potential effects of climate change on food security, changes in biomass production and composition of pigment induced by variation in ambient temperature were examined in fluted pumpkin (*Telfairia occidentallis*), an important vegetable in Nigeria. Ameliorative effect was demonstrated by addition of compost. The plants were grown under a controlled environment (growth chambers): a 10 h photoperiod and ambient temperature ranges of 30-32 ^{0}C, 33-35 ^{0}C, 36-38 ^{0}C and 39-41 ^{0}C with two other natural growth units (27-29 ^{0}C) as control. The plants were grown under screen house for 95 days. Agronomic parameters such as plant height, root length and plant yield and biochemical components (chlorophyll a and b and carotene) were determined. Results showed that elevated temperature decreased bio-chemical properties by 29 % (at 30–32 ^{0}C) and 34 % (at 36-38 ^{0}C) for total chlorophyll (Chlorophyll a and b) and 0.6–11 % (at 30-41 ^{0}C) for carotene. With organic compost amendments, chlorophyll a and b and carotene levels increased and growth advanced from 219-340.3 cm, 30–65 g and 5–9 g for height, shoot biomass and root biomass respectively. For the control (without compost), the measured parameters decreased. Increasing ambient temperatures adversely affected photosynthetic pigment production thus putting food security at risk while the adverse effect was mitigated by application of compost.
Keywords: chlorophyll a and b, carotene, plant biomass, ambient temperature, climate change, global warming, food security.

1 Introduction

The concept of global warming includes gradual increase in world temperatures caused by greenhouse gases such as carbon dioxide, nitrous oxide, chlorofluorocarbons, methane, sulphuric fluoride and some organo-chloride compounds, released by human activities [1]. Projection on global temperature increase was 1.8-4.0°C in the next few decades given that the Earth's temperature is likely to rise by about 0.1-0.2°C per decade [2]. Recent occurrences of global warming may accelerate to detrimental levels with consequent adverse effects in the near future in several countries [3, 4].

Considering the climate of Nigeria, it is mainly tropical in nature. That is, temperatures are high throughout the year, average ranging from 25 °C to 28 °C. Northern Nigeria experiences greater temperature extremes than the south. Based on the IPCC projection [2], the humid tropical areas of Southern Nigeria are expected to be characterized by increase in both precipitation and temperature. Some adverse effects may therefore be expected.

Certain adverse effects of climate change in Nigeria have been identified [5] and these are persistent droughts, flooding, off-season rains, drying up of lakes, over 100000 farming families moving southwards as a result of the desertification, increasing incidence of disease, declining agricultural productivity, and rising number of heat waves.

Nigeria is vulnerable to the various predicted impacts of climate change, and therefore the phenomenon of climate change becomes a subject of concern to the Federal Government of Nigeria. Hence, efforts of the Department of Climate Change, Federal Government of Nigeria [6] to meet up with the challenges include the following: one, implementation of both the Climate Change Convention and its related Kyoto Protocol at international as well as national levels; two, desertification process; three, special climate change fund; four, Clean Development Mechanism (CDM) projects; and five, Capacity Development for Clean Development Mechanism. There seems to be not much on combating climate change effects on agriculture and food security, perhaps because substantial information or research on climate change effects on agricultural production in the context of Nigeria environment is lacking.

Regarding developing countries in particular, climate change is foreseen to have a negative impact on food security and food safety, envisaging substantial decline in African crop production [7]. Food production is said to be a basic component of national economy [4]. Hence, agricultural policies in Nigeria tend towards food production.

In view of challenges of climate change to food security, there is a projection that by the year 2020, half of Nigeria's agro-ecological zones will not have their demand for food met with local supply, considering that increased temperature will trigger higher livestock mortality rates as well as reduced yield from rain-fed crops [8].

Several global climate changes relevant to agriculture have been predicted and these include temperature increase, variation in precipitation, drought and atmospheric carbon dioxide [7]. And it is already envisaged that in Africa, both commercial and subsistence farming will be affected by adverse climate change [3].

Since the said climate changes are likely to shift the timing and length of growing seasons geographically, planting and harvesting dates as well as deterioration of soil quality (considering that nutrients and trace elements can be externally or internally bound to various components, which affects their concentration and speciation in the soil solution) [7], there is the need for ameliorative measures like application of compost. Some of the suggested land management options to combat the effects of climate change are conservative agricultural practices such as integrated soil fertility management and agro-forestry; and in particular, nutrient management through manure and residues (compost) was said to be effective [8].

The growing food demand and the threat of heavy crop losses due to global warming impose the urgent development of strategies to substantially improve food availability. To better understand the phenomenon of climate change in relation to food security within the context of Nigeria environment, this study was carried out. The aim is to ascertain the effect of increasing temperature on chlorophyll a and b, carotene and some agronomic properties of Fluted Pumpkin (*Telfairia occidentallis*), a rich popular vegetable widely grown in Nigeria; and to investigate the ameliorative effect of composting on crop plants grown under abnormal temperature condition.

2 MATERIALS AND METHODS

2.1 Study location

The research was carried out at College of Environmental Resources Management, University of Agriculture Abeokuta along Alabata road in Odeda local government area of Ogun state, Southwestern Nigeria. It is situated between Latitude 7.9°N and 7.8°10'N and Longitude 3^0 23'E and 3° 24'E, with average daily minimum and maximum temperature of about 21 ^{0}C and 35 ^{0}C respectively.

2.2 Temperature chambers

Temperature chambers were constructed with wooden material wrapped with aluminum foils, and glass materials (**Fig.** 1)

Fig. 1 Temperature chambers

Temperature variations during the experiment were achieved via installation of incandescent (240CV2 JUNSGAM0) electric bulbs of varying wattages (60 watts, 100 watts, 200 watts and 300 watts). For instance, where possible, two bulbs were connected together to obtain the desired temperature regime. Each of the temperature chambers was 7 cm in length, 5.5 cm in breath and with height of 7.5 cm, giving a volume of 288.8 cm^3. The chambers were constructed with the view that each would contain four experimental pots. A total of six chambers were established with different temperature ranges (Table 1).

Table 1: Description of experimental systems used in the screen house study

S/N	Temperature range (maximum & minimum temp. obtained during 10 hrs lightening period)	*System description	System code	Number of replicate
1.	A27-29 ^{0}C	Soil alone, outside the temperature chamber	Soil alone 27-29	4
2.	B27-29 ^{0}C	Soil + compost amendment, outside the temperature chamber	Soil + compost 27-29	4
3.	30-32 ^{0}C	Soil + compost amendment, inside the temperature chamber	Soil + compost 30-32	4
4.	33-35 ^{0}C	Soil + compost amendment, inside the temperature chamber	Soil + compost 33-35	4
5.	36-38 ^{0}C	Soil + compost amendment, inside the temperature chamber	Soil + compost 36-38	4
6.	39-41 ^{0}C	Soil + compost amendment, inside the temperature chamber	Soil + compost 39-41	4
Total number of pots = 24				

*Each system was contained in a pot.

2.3 Preliminary Investigation

The crop suitable for this study should be temperature tolerant. In order to select crop for the experiment, preliminary tests were conducted to determine crop that could survive the working temperatures. Plants tested were: (i) Okro (*Abelmoschus esculentus),* (ii) spinach (*Amaranthus hybridus),* (iii) Eggs plant (*Solanum melongena var. esculent),* (iv) Plume Cockscomb *(Celosia argentea),* (v) Fluted Pumpkin (*telfairia occidentalis)* and *(*vi) Corn *(Zea maize).*The plants were grown with 4 replicates at the temperature ranges of 36-38 ^{0}C and 39-41 ^{0}C, for four weeks. Based on agronomical parameters, the crops' thermophiles potential decreased in the order: *Telfairia occidentalis* > *Zea maize* > *Abelmoschus esculentus* > *Solanum melongena* > *Amaranthus hybridus* > *Celosia argentea*. Hence, *Telfairia occidentalis* evolved as the crop with highest thermophilic potential.

2.4 Soil preparation

Soil sample preparation included removal of foreign bodies such as sticks, stones and glasses, air-drying at ambient temperature of 30 ^{0}C, and crushing to pass through a 2 mm mesh sieve. The samples were then transferred to designated brown plastic pots of 5 L capacity, at 3 kg soil per pot; watered at appropriate field capacity and allowed to stand for 21 days. This was followed by mixing with 0.5 % (w/w) compost made from poultry droppings and saw-dust per pot. The composition of the compost was such that it would serve as a source of carbohydrate, nitrogen, raw ingredient for humus formation, moisture and to provide appropriate soil aeration. The carbon to nitrogen ratio was adjusted between 25:1 and 35:1. After seven days, sub-samples were collected from each pot and analyzed using standard procedures for the following parameters: pH, particle size distribution, organic compost, content, organic carbon, cation exchange capacity and electrical conductivity.

2.5 Screen house experiment

Twenty four pots were set up for the experiment, consisting of 6 treatments with 4 replicates. After filling each pot with 3 kg soil, the pots were transferred to the screen house, and placed according to the description in Table 1. Each temperature chamber contained four replicates of a given system. To prevent loss of matter from the pots, no real drainage was made but to avoid flooding, soils were watered at the required field capacity. After the initial watering, four viable seeds of fluted pumpkin (*Telfairia occidentalis*) were sown in each pot and later reduced to one plant per pot after germination. Watering was carried out as required by the crop.

2.6 Assessment and monitoring of plant agronomical and biochemical parameters

Agronomical parameters monitored were (i) germination period (ii) number of leaf, (iii) leaf area; (iv) stem girth, (v) root length and (vi) shoot height (vii) Chlorophyll a, b and carotene. The growth season lasted for four months (October to January).

2.6.1 Pre-harvest bio-monitoring

The monitoring method followed that described by Patil and Bodhe [9]. Germination period, plant height, stem girth, leaf number and leaf area were monitored at regular interval of time; plant height (in centimeter) was measured on weekly basis. Plant height was considered as the aerial part of the plant from the soil level to apex. Stem girth was also measured using thread which was later read on meter rule, the numbers of leaf was determined via counting and the leaf area was determined using the graphical method. The leaf whose area was to be measure was placed on the graph paper, with smallest grid size of 1x1 mm. Leaf was outlined with a sharp edge pencil accurately and carefully on the graph paper. The total number of grids covered by outline edge of the leaf is calculated; if edge outline occupied more than one half grids of graph paper, it was treated as one, otherwise zero. The number of grid count corresponded to the actual area of the leaf

2.6.2 Post- harvest assessment

Parameters measured include root length, biomass production by gravimetric method, carotene levels and chlorophyll pigment (total, a, and b chlorophylls).

2.6.3 Root length measurement

At the end of the experiment, plants were harvested and the roots were cleaned of adhering soil particles, washed with distilled water and sun dried. The length of the longest root was recorded in centimeter.

2.6.4 Determination of fresh and dry weights

Plant tissues were carefully separated to shoot and root and then cut to reduce particle size. Fresh weight was the initial weight. The roots and shoots were dried to constant weight to give dry weight of matter. This was done by drying at about 50-72 ^{0}C hours.

2.7 Chlorophyll contents determination

Chlorophyll a and b components were quantitatively analyzed by absorption spectrophotometry method. One gram of fresh plant tissue (leaf) was ground in porcelain mortar; this was followed by extraction with acetone (HPLC grade); made up to volume with distilled water until all the colour pigment was released from the tissue. The mixture was made up to 100 ml volume and Absorbance read at the desired wavelength of chlorophyll a, b, and total chlorophyll [10]

Chlorophyll a (ugml^{-1}) = 12.25 (A663.6) – 2.55 (A646.6)

Chlorophyll b (ugml^{-1}) = 20.31 (A646) – 20.31 (A663.6)

Total chlorophyll (ugml^{-1}) =17.76 (A646.6) + 7.34 (A663.6)

2.7.1 Vitamin A or Carotene levels determination

2 g of each sample was weighed into a flat bottom reflux flask, 10 ml of distilled water added shaking carefully to form paste. 25 ml of alcohol KOH solution was added under reflux condenser. The above mixture was heated in boiling water bath for 1 hour shaking frequently. The mixture was cooled rapidly and 30 ml of water was added. The hydro lysate obtained was transferred into a separated funnel. The solution was re-extracted three times with 25 ml quantity of chloroform. This was followed by the addition of 2 g anhydrous $NaS0_4$ to remove traces of water, the mixture was then filtered into 100 ml volumetric flask and made up to mark with chloroform. Standard solution of B-Carotene Vitamin A of range 0-50 mg/ml with chloroform by dissolving 0.003 g of standard B in 100 ml of chloroform, the above gradients of different standard prepared were determined from which average gradient was taken to calculate Vitamin A (B-Carotene in mg/100 g), the absorbance of the samples and standards were read on the spectrometer at a wavelength of 328 nm on a spectrophotometer.

Calculation

$$\text{Carotenoid (Vitamin A)}\left({}^{\mu g}/_{100g}\right) = \frac{(\text{Absorbance of sample} \times \text{gradient factor}) \times 10}{\text{Weight of sample} \times 1000}$$

2.8 Statistical analysis

Statistical analysis was carried out using SPSS version 16.0. Data were subjected to descriptive statistics and as well, ANOVA was determined. Pearson correlation coefficient was used to determine the relationship between temperatures variation, biomass productions and biochemical parameters.

3 RESULTS AND DISCUSSION

3.1 Temperature variation

The temperature dynamics achieved in the chambers ranged from 27-41^{o}C; while the daily atmospheric temperature in the environment of the experimenting chambers varied from 23-27 ^{o}C, 29-41 ^{o}C and 29-35 ^{o}C, for morning, noon and evening respectively. This shows that the temperature ranges chosen for the experiment was very similar to the actual daily atmospheric temperature of that geographical location and hence the agronomic and biochemical observations on the experimental plant might in a way be a reflection of what obtains in the real life. The observations in this study may therefore inform some policy advice on effects of climate change on agriculture, and hence food security in Nigeria, and the world in general. The forecast on global temperature increase is put at 1.8 to 4^{0}C in the next few decades [2] given that the earth temperature is likely to rise by about 0.1 to 0.2 ^{0}C per decade. One may then imagine what the temperature scale will look like, especially in the tropical regions. There is the need for proactive steps to forestall the impending disasters.

Furthermore, studies have shown that plants have potentials to adapt to high ambient temperature changes and can usually adjust (positively or negatively) to conditions slightly below or above normal temperature ranges [11]. Physiological adaptations to high ambient temperatures include change in leaf orientation, increased leaf wax, leaf rolling, change in leaf size and the production of heat shock proteins [12], while negative adaptations may result in cumulative effects of reduced agricultural production.

The agronomical characteristics showed that the recorded germination period fell within twelve to twenty days for all the experimental seeds both the treatments and in the control chambers, and about 60 % germination was observed. This agrees with the observations of Adekunle *et al*. [13]. The longer germination period could be due to the fact that the seeds have thick meso-carp which may not allow for easy sprouting. At this stage, the effect of increasing soil temperature was unnoticed since 40 % failure in germination was observed both in the treatment and in the control chamber.

Table 2: Plant height (cm) of *Telfairiaoccidentalis* with ambient temperature

Range	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	WK12
27-29^{0}C	A11.5^a	23.3^a	43.6^a	80.5^a	128^a	148.6^a	124.8^b	187.5^a	201.8^b	210^a	211a	213^b
27-29^{0}C	B9.3^{ab}.	20.5^a	41.8^a	76.8^a	137.8^a	162^a	194.3^{ab}	225^a	256.3^{ab}	302.5^a	312.5^a	323.3^a
30-32^{0}C	10.0^{ab}	20.5^a	46.5^a	82.6^a	105.3^a	162.5^a	205^{ab}	226.3^a	261.3^{ab}	295.8^a	307.8^a	326.8^a
33-35^{0}C	8.6^{ab}	28^a	54.8^a	109.5^a	155.5^a	195.5^a	226.3^a	257.5^a	293.8^a	318.3^a	330.3^a	340.3^a
36-38^{0}C	6.3^b	15.3^a	42.8^a	96.3^a	145^a	180.5^a	221.3^a	245.8^a	283^{ab}	314.8^a	325.5^a	336.8^a
39-41^{0}C	6.3^{ab}	14.3^a	41^a	84.3^a	121.8^a	152^a	189.5^{ab}	222.3^a	250.0^{ab}	274.8^a	285^{ab}	294.3^{ab}

WK = week; values in the same column and with different superscript are significantly different at $P \leq 0.05$

3.2 Plant height

Plant heights (Table 2) ranged from 11.1 ± 2.6 to 213±45.4 (cm) for control (at 27-29 ^{0}C); and for compost-amended soil, the ranges were 9.25 ± 2.2 to 323± 21.4 (cm), 10 ± 3.6 to 326± 78.6 (cm), 8.75 ± 2.5 to 340 ± 21.1 (cm), 6.25 ± 0.96 to 336 ± 43.1 (cm) and 6.25 ± 0.95 to 294± 96.0 (cm) at 27-29 ^{0}C, 30-32 ^{0}C, 33-35^{0}C, 36-38 ^{0}C and 39-41 ^{0}C respectively.

Generally, the observed plant height increased with the growing period. However, for plants in soil alone (control) at temperature range of 27-29 ^{0}C, stunted growth was noted. This might be as a result of nutrient deficiency, implying that the compost applied to the others had ameliorating effect on soil nutrient deficiency. Conservative agriculture (with application of compost or manure in particular) may thus boost agricultural yields.

Considerable growth was observed at a temperature range of 30-38 ^{0}C. This agrees with some authors that shoot height increased with elevated ambient temperature [14, 15). However, there was drastically slower growth for plants in chambers with temperatures higher than 38 ^{0}C. The decrease observed above this temperature suggests that optimum ambient temperature for growth might be around 30-38 ^{0}C, above which plant growth may suffer negative impacts. Atmospheric temperatures recorded around the noon in the location of this study exceeded 38 ^{0}C. This may be a warning signal for agriculture in such environmental conditions.

Again, looking at the effect of soil amendment, plant height was higher in the chambers with compost-amended soil than the corresponding chambers containing soil without compost (control). This implied improvement in nutrient status in the pots where organic compost was applied. Mean variation of the plant heights was significant at $P \leq 0.05$. Also, contrary to expectation, increase in temperature (and water supply) favoured biomass production of the plants. Perhaps this is as a result of ameliorative effect of the compost. Primitive agriculture had actually drawn its strength from sole dependence on organic fertilizer as a cheap and alternative to mineral fertilizer. Several studies have shown that composts contain macro and micro elements required for proper plant growth [16]. Composting plays a dual role of reducing the organic waste volume (sustainable agro-waste management) as well as making some organically bound mineral elements in soil available for plant use [16]. Other studies [17, 18] show that it improves soil structure, allowing good soil aeration, appropriate moisture retention, soil temperature regulation and even bioremediation of contaminated soil.

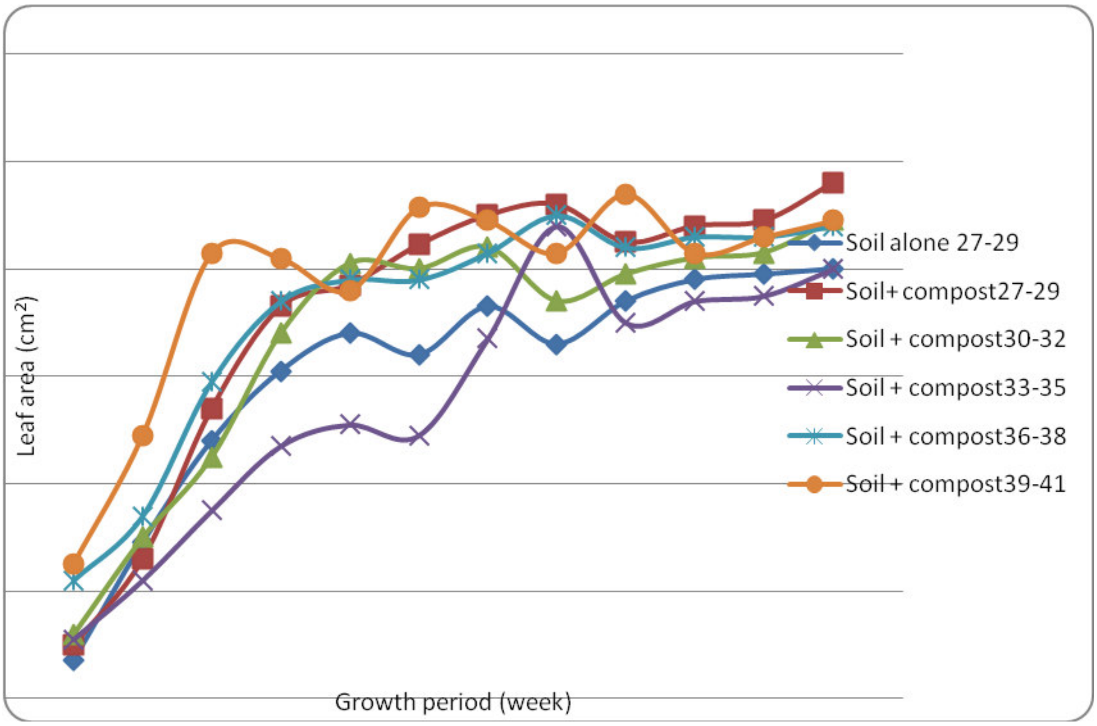

Fig. 2 Leaf area variations of *Telfairiaoccidentalis,* (indicating error bars with standard error)

3.3 Leaf area

The size (cm^2) of leaf area (**Fig.** 2) ranged from 13.5 ± 1.9 to 50.0 ± 13.7 for control at 27-29^{0}C, while others ranged from 15.0 ± 5.3 to 58.0 ±13.9, 16.0 ±1.6 to 54.5± 12.3, 15.5±1.9 to 50.0 ± 10.1, 21.0 ± 7.4 to 54.0 ± 11.4, and 22.5 ± 9.0 to 54.0 ± 17.0 (m^2) for Soil + compost at 27-29 ^{0}C, 30-32 ^{0}C, 33-35, 36-38 and 39-41^{0}C respectively. Leaf area increased with organic compost addition by 16 % more than the treatment without organic compost.

Temperature effect gave 6.0-13.75 % decrease which showed that leaf area was adversely affected by increasing temperatures. Pappadoulus *et al.* , [15] made similar observation that leaf areas of seedless cucumber grown at elevated temperature decreased with increasing temperatures. This may also imply reduced photosynthesis and thus food shortage with increase in temperatures.

Leaf number increased with the growth period except for Soil alone 27-29 where growth became stunted toward the end of the experiment, probably as a result of nutrients deficiency. Mean variation of the leaf numbers was significant ($P \leq 0.05$) at week eleven and twelve. The numbers of leaves increased with increasing temperatures, most especially in Soil + compost at 33-35 ^{0}C and thus showing that leaf growth and development is optimal at this level above which a percentage decrease of 6.0 - 13.75 % was observed in leaf numbers. It revealed that although leaf numbers increased with increasing temperature, it has optimum value above which leaf growth is hindered. Marschner [19] had similar findings that leaf number increased with increasing temperature. The effect of temperature therefore could be immense in food production since the photosynthetic process does occur in green leaves; any adverse implication may imply food shortage. Leaf numbers increased with organic compost addition by 16 % more than the system without organic compost. The effect of temperature was noticeably reduced by compost application.

3.4 Stem girth

Application of organic compost resulted in 1.67 % increase in stem girth probably as a result of increased nutrients status while temperature effect was silent. No significant variation was observed in stem girth.

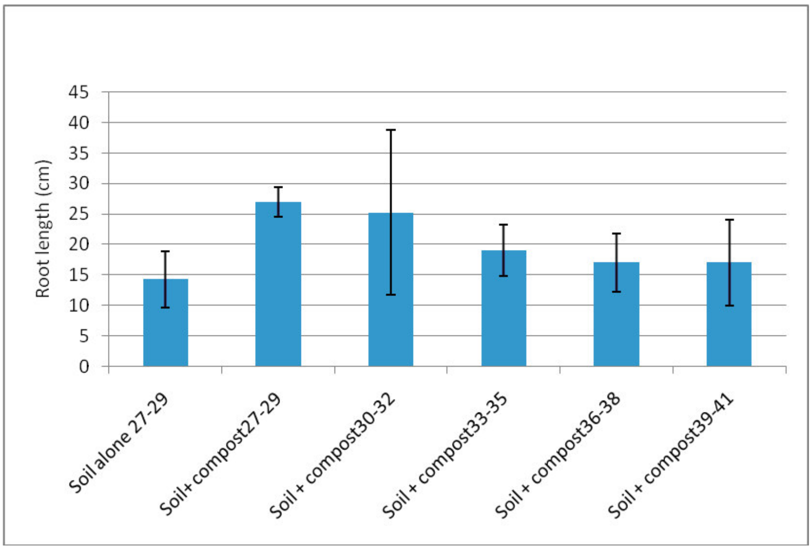

Fig. 3 Root length variation of *Telfairia occidentalis* (indicating error bars with standard error)

3.5 Root length

Root length (**Fig.** 3) increased with compost amendment by 98 % but decreased with increasing temperature by 6.4-37 % (30-41 ^{o}C). While the least (17 cm) was observed in Soil alone at 27-29 ^{o}C, the longest (27 cm) was recorded in Soil + compost at 27-29 ^{o}C.

The result suggests that increasing temperature did not favour root growth and development of *Telfairia occidentalis*. Plant root however have been reported to have optimal temperature for normal growth [20], thus increasing temperature would accelerate desertification since plant's root growth and development is heavily hampered. This could be linked with the increasing desertification trend in the northern part of Nigeria.

The growth of plant root may be affected by the physical properties of soil such as temperature, texture, and moisture, as well as the chemical properties of soil including pH, salinity and heavy metal contents. The structure of membrane lipids in roots also changes, and the activities of enzymes on the membrane responsible for nutrient uptake such as Adenosine-tri-phosphatase decreased [21]. Pregitzer et al. [22] reported that root growth is often limited by low (sub-optimal) and high (supra-optimal) soil temperatures, hence, as soil temperature increases toward optimal, the root activity of the crop itself increases with temperature.

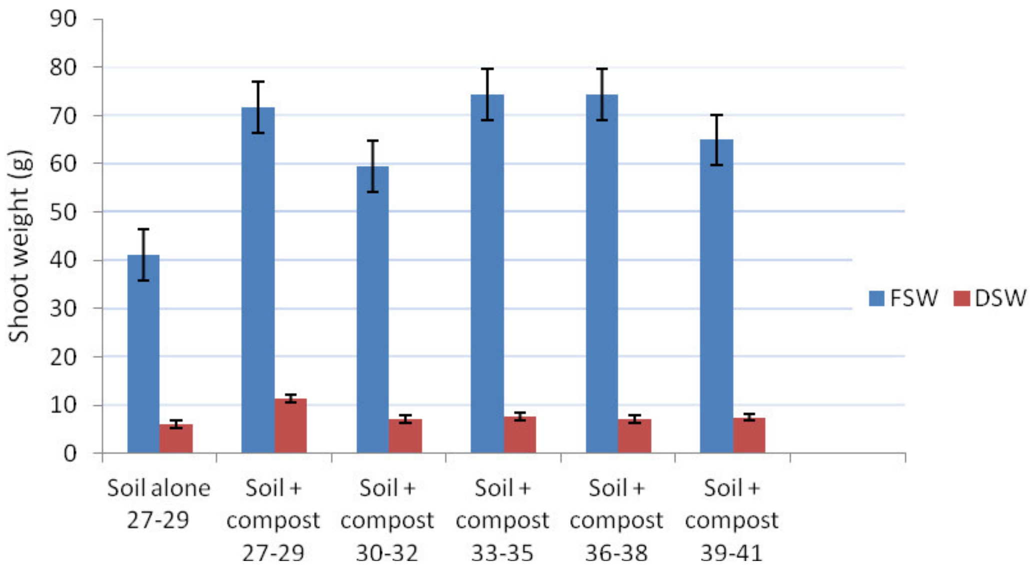

Fig. 4 Shoot biomass – fresh (FSW) and dry (DSW) shoot weight variation of *Telfairia occidentalis* (indicating error bars with standard error)

3.6 Shoot biomass

Fresh and dry shoot weights (**Fig.** 4) increased by 18.4 % and 58.5 % respectively with organic compost amendments more than the system without organic compost. Increasing temperature from 30 to 35 ^{0}C gave 31 % to 45 % increase above which biomass weight decreased slightly (36-41 ^{0}C).

The shoot weight increased at 30-35 ^{0}C and showed that the plant could possibly grow best at this temperature range with organic compost amendment, above which it may be adversely affected.

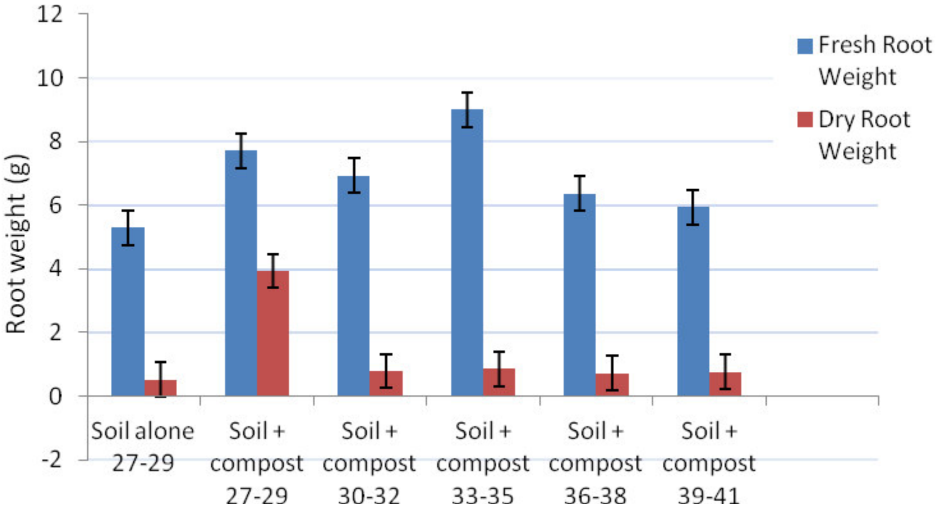

Fig. 5 Variation of root biomass yield of *Telfairia occidentalis* (indicating error bars with standard error)

3.7 Root biomass

Soil amendment increased the root biomass production of the plant by 45 %. However, 10-22 % decrease was noted with temperature rise (30-41 ^{0}C), showing that root biomass decreased with increasing temperatures (**Fig.** 5). This revealed that increasing temperatures adversely affected root development, thus causing poor root growth and development, low yield and plant's death. Similarly, Fritioff et al. [14] and Wahid et al. [23] observed that plant dry weight decreased with increase in temperature. Total plant biomass in all the treatments with organic composts was higher than the corresponding non-composted pots. Both shoot and root weights were found lower in soil alone at 27-29 ^{0}C.

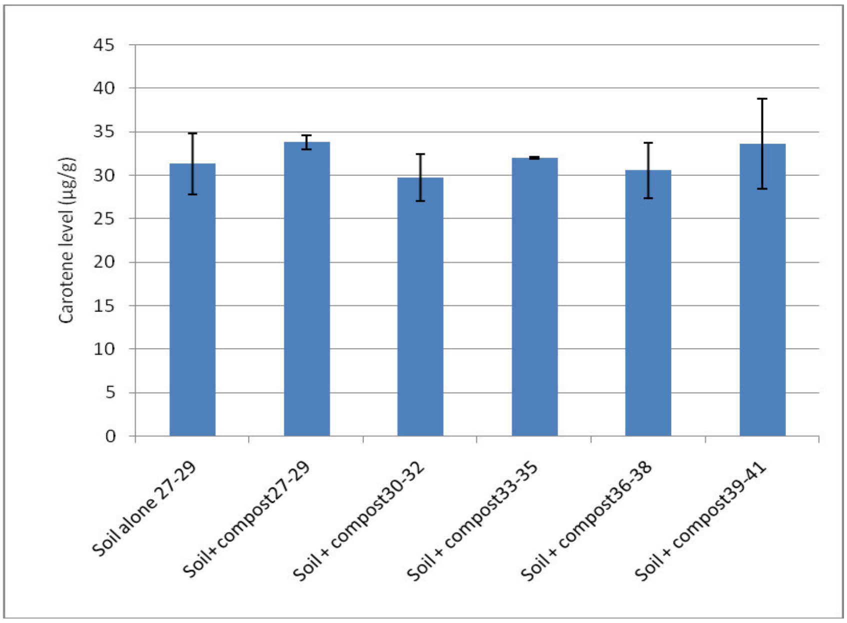

Fig. 6 Variation in carotene levels of *Telfairia occidentalis* (indicating error bars with standard error)

3.8 Carotene levels

Carotene levels (**Fig.** 6) ranged from 29.76$\pm$ 80.40 to 33.82$\pm$ 27.09 (µg/100 g). The least was observed in Soil + compost at 30-32^{0}C (29.76 µg/100 g) while the highest carotene level was observed in Soil + compost at 27-

29^{0}C (33.82 µg/100 g) respectively. Carotene levels increased by 8 % with organic compost addition more than treatment without soil amendments. Generally, the level decreased by (0.6-11 %) with rising temperatures at 30-32^{0}C and 36 – 38^{0}C, showing that increasing temperatures may adversely affect carotene pigment formation. However, above 38 ^{0}C, production increased. Other hidden processes may account for this. No significant variation was observed in the mean values ($P \leq 0.05$). Carotene composition and production under these temperature range seemed optimum since no real negative trend was observed probably as a result of the compost added.

Leaf carotenoids have essential photo-protective roles: they scavenge reactive oxygen species, quench dangerous triplet states of chlorophyll and participate in thermal dissipation of excess light energy, increased plant tolerance to high temperature and low temperature [24]. Nemeskéri, [25] reported that there was a sharp increase in the carotene level in the leaves of drought-stressed green beans when the temperature during flowering was 30/15 °C, but in plants exposed to 35/25 °C during flowering the level dropped to near the control level. Differences between the varieties in their adaptability to drought and heat could be detected as changes in the chlorophyll and carotene contents of the leaves even at 30/15 °C.

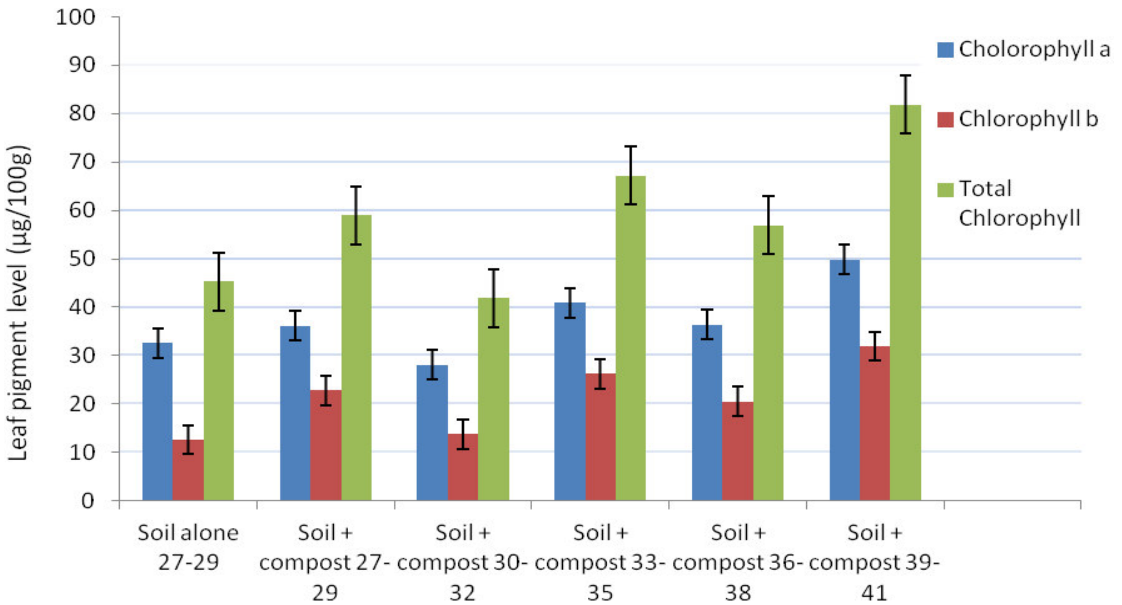

Fig. 7 Variation of chlorophyll a, b and total chlorophyll of *Telfairia occidentalis* (indicating error bars with standard error)

3.9 Chlorophyll a and b

Chlorophyll a, b, and total chlorophyll levels (**Fig.** 7) ranged from 32.63 $\pm$ 20.22 (µgml^{-1}) to 52.63 $\pm$ 10.04(µgml^{-1}), 12.66$\pm$ 9.18 (µgml^{-1}) to 33.66$\pm$ 9.18 (µgml^{-1}) and 41.9 $\pm$ 19.16 (µgml^{-1}) to 86.26 $\pm$ 19.20 (µgml^{-1}) respectively. Total chlorophyll formation increased by 30 % with compost addition. This showed that organic compost could positively impact photo-synthetic pigments production. Temperature effect increased total chlorophyll by 29 % and 34 % at temperature range of 30-32 ^{0}C and 36-38 ^{0}C respectively, the production was highest at temperature range of 39-41^{0}C (86.26 µgml^{-1}). This shows that the amount of chlorophyll formed in plants is strongly influenced by environmental factors including temperature changes, and that pigment formation is relative to temperature. This agrees withYun *et al*., [26].

4 CONCLUSION

Results showed that elevated temperature can potentially affect plant bio-chemical properties: total chlorophyll (Chlorophyll a and b) and carotene. With organic compost amendments, chlorophyll a and b and carotene levels increased, showing the potential of compost to ameliorate the adverse effects. With compost application, growth advanced – increase in height, shoot and root biomass. However, dry weight of the biomass decreased with increasing ambient temperature. Significant correlations were obtained between biomass production and biochemical parameters. Increasing ambient temperatures adversely affected photosynthetic pigment production thus putting food security at risk while soil amendments with compost improved the condition.

The result revealed that increasing temperature resulting from global warming could negatively impact agriculture, putting food security under threat, and that this adverse effect can be mitigated with the use of conservative agriculture as adaptation measures in mitigating against the negative impact of increasing global temperature; thus individual, community and nation should buy this idea of mitigating efforts in that it is cheap and readily available.

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