**Vine length, Fruit Lycopene and Carotene contents as influenced by Fertilizer, Salinity and Bicarbonate treatments in Snake tomato (*Tricosanthes cucumerina* L.)**

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**ABSTRACT**

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| **Aim:** To determine the influence of fertilizer, salinity, and bicarbonate treatments on vine length, fruit lycopene and carotene contents in snake tomato (*Tricosanthes cucumerina* L.)  **Study design:** Complete randomized block design (CRBD).  **Place and Duration of Study:** This study was carried out under a screen house at the botanical garden of the Department of Botany, Nnamdi Azikiwe University, Awka located on Latitude 6.25/Longitude7.11 and experiments was carried out from August to November, 2024.  **Methodology:** Seeds were planted in 30 liters volume black plastic buckets, germinated seedlings were irrigated with tap water till 21 days after germination before watering with 2mM of NaCl, NaHCO3 and KHCO3 water at 7 days interval. Inorganic fertilizer of NPK (15:15:15) was applied at the rates of 7 g per pot at 14 days after germination, while organic fertilizer of poultry manure was applied 14 days before seed planting and combined fertilizer treatment at the ratio 1:1 was used. The treatments comprised of fifteen treatments with five replicates randomly set out. Treatments are control, Inorganic+NaCl, Inorganic+NaHCO3, Inorganic+KHCO3,Inorganic+NaCl+NAHCO3,Inorganic+NaCl+KHCO3, Organic+NaCl,Organic+NaHCO3,Organic+KHCO3,Organic+NaCl+NaHCO3, Oganic+NaCl+KHCO3,Combined+NaCl,Combined+NaHCO3,Combined+KHCO3, Combined+NaCl+NaHCO3 and Combined+NaCl+KHCO3.  **Results:** Results were analyzed with ANOVA, and means were separated using Duncan’s multiple range test, confidence level was *P = .05.* Results showed that growth generally progressed from seedling stage up to 12 weeks. Inorganic fertilizer treatments with salinity and bicarbonates initially gave higher vine length, followed by combined fertilizer which later outperformed it. Organic fertilizer generally gave lower growth rate. At week 10, combined+KHCO3 had highest vine length of 578.03±8.45 cm, followed by Combined+NaCl+NaHCO3 - 574.53±9.96 cm, while Organic+NaCl had the least of 403.23±59.33 cm and control had 505.63±18.27. There was significant effect of the treatments on lycopene content, which showed Combined+NaHCO3 had the highest effect of 85.90 ± 0.65 mg/100 g, followed by combined+NaCl+NaHCO3 which had 84.91 ± 0.33 mg/100 g and the carotene content by same treatment had 2.48 ± 0.07 mg/100 g and for carotene 2.32 ± 0.09 mg/100 g.  **Conclusion:** Plant vine length was influenced by treatments, however fruit yield of lycopene and carotene was on the other hand influenced by treatments. |

*Keywords: snake tomato, bicarbonates, antioxidants, lycopene, carotene*

**1. INTRODUCTION**

The need for food availability among poor sub-Saharan Africans is prompting the research into providing alternative sources especially when their economic status could not sustain importation of canned tomato paste for the poor populace. The closest alternative obvious is snake tomato (*T. cucumerina*). The plant yielded pastes used in preparing recipes for eating rice especially among households. The fruits of snake tomato has the size, production not cost intensive, and it possesses nutritional and medicinal properties of importance. This research was carried out to ascertain nutritional treatments towards improving snake tomato growth and fruit yield of important bioactive compounds such as lycopene and carotene which are of good antioxidant effect.

Nigeria’s tomato hike in price of tomato is over 320%, from N547.28 in June of year 2023 to N 2,302.26 in June 2024 (NBS Executive Summary, 2024). Nigeria can only account to be producing 10% of all the tomato paste used in Nigeria and that is grossly an under supply to the demands of the population (Tomato News, Daily Trust, Jan. 27 2024). Most households find it difficult to have adequate food and more especially quality tomatoes to meet their culinary need. Alternatives are being sought by people to ameliorate the present striking effect of low production and high cost of tomato and tomato paste. Some alternatives includes red bell pepper, carrot and beets, palm fruit extract '*ofe-akwu*' and so on. These have actually not met the demand for known traditional tomato (Farming Farmers Farm, 2023).

Snake tomato, *Tricosanthes cucumerina* L. is also known as snake guard by different tribes group. It is an annual, monoecious, tropical or subtropical plant of culinary and medicinal status and is being underutilized (Abukusa-Onyago, 2003; Idowu, 2019). In Nigeria, about 50% of the harvested ripe fruit of *T. cucumerina* are wasted as a result of spoilage (decay) while about 40% of the ripe fruits are not even harvested fruits from the farm. The wastage associated with the fruit is thus enormous and farmers are no longer, interested on cultivating the crop, the agronomic advantages not withstanding (Onyeka, 2002). Tomato paste is scarce in terms of making it available in Nigeria, therefore alternatives are been sought to augment availability of tomato paste for culinary uses. The usefulness of the plant, snake tomato, includes that it is highly nutritious, a good source of vitamins, and gives several medicinal values which include treatment of fever, cough, dysentery, headache, skin rashes and alopaecia (loss of hair or baldness) (Idowu *et al*. 2019). *T. cucumerina* is underexploited or neglected with numerous potentials of the fruits and seeds, which shows it contains fat, soluble vitamins, proteins, carbohydrates, lipids, crude fibre. Mineral elements found are, Mg, Cu, K, Zn, Ca, Na, N, P, Pb, Ag, Fe, Se, Cd, Pb, Cr, Co, Ni and Hg. Also present are phytochemicals – oxalate, tannins, soponins, phytate, tyrosin-inhibitor, flavonoids, hydrogen cyanide, alkaloids, phenols, and glycosides (Izundu *et al*., 2011, Liyanage *et al*., 2016, Okonwu, 2019).

Sodium bicarbonate is a pH buffer, promotes nutrient uptake and enhances how plants cope with abiotic stress and oxidative damage. It is known to add more carbon to the roots of plants thus increases photosynthetic activity of plant cells, increases expression of enzyme of Calvin cycle which helps in CO2 assimilation thereby generating glyceraldehyde-3-phosphate (G-3-P) as well as other precursors to sugar synthesis ( Liang *et al*., 2023, Reinoso *et al*., 2024).

Potassium bicarbonate improves the activation of most enzymes that catalyze the pathway of carbohydrate synthesis, especially sucrose-6-phosphate synthase (SPS) as well sucrose-6- phosphate phosphatase, Fructokinase, and Glucokinase as enzymes contributing to the synthesis of sucrose as well as conversion into other forms of sugars. (Xu *et al*., 2020, Luo *et al*., 2022)

The aim of this study is to evaluate the influence of fertilizer, salinity and bicarbonates on vine length, fruit lycopene and carotene content.

**2. Materials and methods**

Viable seeds of snake tomato (*T. cucumerina* L.) obtained from NRCRI Umudike were planted in 30 litres plastic buckets filled with sandy loam soil, mixed with respective fertilizer. Following germination the seedlings were treated with 2mM of salinity, and or bicarbonate as may be required from 21 days after germination. The saline and bicarbonate treatments were supplied in irrigation water using standard methods of Ogbonna *et al*., (2016). Growth parameter of vine length was observed and recorded. Fruit lycopene and carotene content were analyzed by modified methods of Rodriguez-Amaya and Kimura method (2004), Kumari *et al*., (2011), and Akter *et al*., (2020) while β- Carotene was determined from the dried methanol, using100 mg of extract of snake tomatofruit which was mixed with 10 ml of acetone-hexane mixture (4:6) for 1 min and filtered. The absorbance was recorded at three different wavelengths (453,505 and 663 nm). Data were analyzed using SPSS version 26 for ANOVA and means were separated using Duncan Multiple Range Test (Duncan, 1955).

**3. Results and discussion**

**3.1 Vine Length**

The figure showed the vine length measured in centimeters (cm) of snake tomato as influenced by fertilizer, salinity and bicarbonate treatments. The figure explains steady progression of growth in all the treatments including the control. Combined fertilizers treated with salinity and bicarbonate generally showed higher vine length. Initially, Inorganic+NaCl+KHCO3, showed better performance than other treatments than other treatments up to the 6th week, after which Combined+NaCl+NaHCO3 topped other treatments and was followed by Combined+NaCl+KHCO3 at 11th week. Plants under control treatment showed higher vine lengths compared to those under organic fertilizer treatment in which Organic+NaCl treatment showed the least in the vine length performance. Inorganic+NaCl+KHCO3 and Combine+NaCl+KHCO3 showed close growth performance. Furthermore, statistical analysis showed that the treatment effect was significant on the vine length performance of snake tomato at *P = .05*, Figure 1.

Plant growth has been observed to be improved by fertilizer application, whether inorganic or organic fertilizer. Several recommendations of the amount to be applied for better yield are peculiar to the soil type and nutrient status. Growth have been found to be affected by combination of inorganic and organic fertilizer as reported in the work of (Olaniyi and Ajibola, 2008).

Salinity causes most herbaceous plants to have reduced production, this could be related to the source of irrigation water as it contributes to the salinity state of cultivated soils. These soils are identified to have less yield compared to soils having less or normal salt concentration. High salinity has caused reduction in yield of beans, rice and important crops. The effect of plant production by salinity starts with effect on cellular water potential, affecting transpiration, photosynthesis and eventually quality of fruit and seed of affected plants.(Wondim *et al*., 2020, Mirela C. and Orsolya B. 2021, and Lu Y and Fricke W. 2023).

Bicarbonates are providers of CO2 to the roots of plants, in the work of Burbulis *et al*., (2017), on the effects of potassium bicarbonate on photosynthetic parameters of *Setaria viridis* L. Beauv., when treated with water only and potassium bicarbonate before subjecting them to moderate and severe drought. The findings showed that plants treated with different concentrations of KHCO₃ had improved yields compared to those treated with water only. They reported that this was as a result of the protection of photosystem II components of the plants. However, in this study, KHCO₃ irrigation water had reduced effect than that of NaHCO₃.

**Fig 1 : bicarbonate treatments on vine length**

**3.2 Fruit Lycopene Content**

The result of the influence of fertilizer, salinity and bicarbonate treatments on ripe fruit lycopene content, revealed that the treatments were significantly different at *P = .05*. The treatments showed that Combined+NaHCO3+NaCl+NaHCO3, Combined+NaHCO3 and Organic+NaHCO3, gave the same yield of fruit lycopene content, therefore they are of same significant effect. Moreover, Control, Inorganic+NaCl+KHCO3, Organic+NaCl+KHCO3 e.t.c, gave similar yield but are statistically different from the previous stated treatments. Furthermore, Inorganic+NaCl+KHCO3 gave the least yield of lycopene than the control, Table 1.

Table 1: Influence of treatments on ripe fruit Lycopene content (mg/100 g)

|  |  |
| --- | --- |
| Treatments | Lycopene |
| Control | 84.15±0.94ab |
| Inorg +NaCl | 83.92±0.21ab |
| Inorg+NaHCO3 | 84.85±0.02b |
| Inorg+KHCO3 | 83.94±0.29ab |
| Inorg+NaCl+NaHCO3 | 84.3±0.22ab |
| Inorg+NaCl+KHCO3 | 83.74±0.27a |
| Org+NaCl | 84.41±0.47ab |
| Org+NaHCO3 | 86.3±0.44c |
| Org+KHCO3 | 84.41±0.64ab |
| Org+NaCl+NaHCO3 | 84.58±0.46ab |
| Org+NaCl+KHCO3 | 84.34±0.23ab |
| Combined+NaCl | 84.6±0.58ab |
| Combined+NaHCO3 | 86.03±0.71c |
| Combined+KHCO3 | 84.44±0.39ab |
| Combined+NaCl+NaHCO3 | 84.8±0.47b |
| Combined+NaCl+KHCO3 | 84.93±0.93b |

Key \* M±SD

values not sharing same superscripts are significantly different at *P = .05*

Lycopene and carotenes are phenolic compounds which showed to have more yield in some fruits when the plants are treated with organic fertilizers. Some findings collaborated the study where the use of organic fertilizer vermicompost and glycine additive gave higher results of ascorbic acid, flavonoids, and minerals and increased antioxidant activity compared to inorganic NPK fertilizer, Serri *et al.* (2021). Also, Bilalis *et al*., ( 2018) in their work on the effect of organic and inorganic fertilizer on yield and quality of processed tomatoes, found that organically grown tomatoes gave higher yield in lycopene content and total soluble solids, while those grown with inorganic fertilizer improved on number of fruits per plant and fruit yield.

More lycopene and carotene were yielded by combined fertilizer, especially in plants irrigated with sodium bicarbonates while those treated with potassium bicarbonate gave less, but generally yielded better than the control and those irrigated with saline water.

The result of influence of fertilizer, salinity and bicarbonates treatments on ripe fruit carotene content showed that the treatments were significantly different at *P =.05*. The group of treatments, Organic+NaHCO3, Combined+NaHCO3 and Combined+NaCl+NaHCO3 had high yield of carotene compared to other treatments. They were followed by the group of treatments; Combined+NaCl+KHCO3, Organic+NaCl+KHCO3, Combined+KHCO3, and Organic+NaHCO3. However, the least carotene content was given by the Control treatment, Table 2.

Table 2: Influence of treatments on ripe fruit Carotene content (mg/100 g)

|  |  |
| --- | --- |
| Treatment | Carotene |
| Control | 1.23±0.06a |
| Inorg +NaCl | 1.25±0.01a |
| Inorg+NaHCO3 | 1.68±0.05de |
| Inorg+KHCO3 | 1.33±0.01ab |
| Inorg+NaCl+NaHCO3 | 1.58±0.02cd |
| Inorg+NaCl+KHCO3 | 1.46±0.04bc |
| Org+NaCl | 1.6±0.07cd |
| Org+NaHCO3 | 2.34±0.04g |
| Org+KHCO3 | 1.78±0.13e |
| Org+NaCl+KHCO3 | 2.1±0.18f |
| Org+NaCl+NaHCO3 | 2.17±0.08f |
| Combined+NaCl | 1.61±0.08cd |
| Combined+NaHCO3 | 2.43±0.06g |
| Combined+KHCO3 | 2.12±0.04f |
| Combined+NaCl+NaHCO3 | 2.38±0.02g |
| Combined+NaCl+KHCO3 | 2.05±0.24f |

Key \* M±SD

values not sharing sane superscripts are significantly different at *P =.05*

The result of the influence of fertilizer, salinity, and bicarbonates treatments on unripe fruit lycopene content showed that there were significant difference by the treatments. Combined+NaHCO3 gave the highest yield but was statistically different from Combined+NaCl+NaHCO3, Inorganic+NaHCO3, Organic+NaHCO3, Combined+KHCO3, and Organic+KHCO3 though with close similar effect on lycopene yield. In a similar fashion, Inorganic+KHCO3 and Inorganic+NaCl+NaHCO3 had similar influence but were statistically different from Inorganic+NaCl+KHCO3 and Combined+NaCl+KHCO3, Table 3.

Table 3: Influence of treatments on unripe fruit lycopene content (mg/100 g)

|  |  |
| --- | --- |
| Treatment | Lycopen |
| Control | 33.96±2.79**a** |
| Inorg +NaCl | 35.85±0.42**b** |
| Inorg+NaHCO3 | 39.11±0.66**def** |
| Inorg+KHCO3 | 37.38±0.6b**cd** |
| Inorg+NaCl+NaHCO3 | 37.62±1.16**cd** |
| Inorg+NaCl+KHCO3 | 37.74±0.82**cde** |
| Org+NaCl | 35.88±0.53**b** |
| Org+NaHCO3 | 39.51±0.29**ef** |
| Org+KHCO3 | 38.79±0.01**def** |
| Org+NaCl+NaHCO3 | 38.09±0.33**de** |
| Org+NaCl+KHCO3 | 38.21±0.56**de** |
| Combined+NaCl | 36.15±1.08**bc** |
| Combined+NaHCO3 | 40±0.15**f** |
| Combined+KHCO3 | 38.72±0.03**def** |
| Combined+NaCl+NaHCO3 | 39.08±1.02**def** |
| Combined+NaCl+KHCO3 | 37.8±0.14**cde** |

Key \* M±SD

 values not sharing sane superscripts are significantly different at *P =.05*

Result of unripe fruit carotene content as influenced by fertilizer, salinity, and bicarbonate showed that the treatments were significantly different at p<0.05 analyzed with ANOVA. Result showed that the highest yield of carotene in unripe fruit was Combined+NaCl+KHCO3, while the least yield was control treatment. Inorganic+NaHCO3, Inorganic+KHCO3 and Inorganic+NaCl+KHCO3 were not significantly different, Table 4.

Table 4: Influence of fertilizer, salinity and bicarbonates on unripe fruit Carotene content (mg/100 g)

|  |  |
| --- | --- |
| Treatment | Carotene |
| Control | 0.44±0.04**a** |
| Inorg +NaCl | 0.45±0.01**ab** |
| Inorg+NaHCO3 | 0.49±0.03**abc** |
| Inorg+KHCO3 | 0.48±0.01**abc** |
| Inorg+NaCl+NaHCO3 | 0.49±0.01**abc** |
| Inorg+NaCl+KHCO3 | 0.46±0.03**ab** |
| Org+NaCl | 0.5±0.04**abc** |
| Org+NaHCO3 | 0.54±0.03**cd** |
| Org+KHCO3 | 0.5±0.03**abc** |
| Org+NaCl+NaHCO3 | 0.5±0.01**abc** |
| Org+NaCl+KHCO3 | 0.5±0.02**abc** |
| Combined+NaCl | 0.48±0.04**abc** |
| Combined+NaHCO3 | 0.54±0.03**cd** |
| Combined+KHCO3 | 0.51±0.04**bcd** |
| Combined+NaCl+NaHCO3 | 0.5±0.07**abc** |
| Combined+NaCl+KHCO3 | 0.58±0.06**d** |

Key \* M±SD

values sharing same superscripts are not significantly different at *P =.05*

**4. Conclusion**

The use of fertilizers for growing snake tomato has shown that better yield in terms of growth and important antioxidants content in the fruit in the form of lycopene and carotene is achievable by using a combination of inorganic and organic fertilizer with bicarbonates especially that of sodium. Inorganic provides rapid release of mineral nutrients into the soils faster than the organic fertilizer. Therefore the best application is an integrated fertilizer application.

**Definitions, Acronyms, Abbreviations**

CO2: carbon (iv) oxide

NaCl: sodium chloride

NaHCO3: sodium bicarbonate

KHCO3: potassium bicarbonate

ANOVA: Analysis of Varians

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