Influence of Nutritional Treatments on the Mineral of Dwarfgem Tomato Variety (Solanum Lycopersicum Var Dwarfgem L)

Eze, Hope Nkiruka and Izundu, Alexander Ikechukwu

Botany Department, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

This work was carried out in collaboration between the authors. Both authors read and approved the final manuscript.

DOI: https://doi.org/10.51244/IJRSI.2025.120800219

Received: 09 May 2025; Accepted: 06 June 2025; Published: 24 September 2025

ABSTRACT

It is known that in Nigeria, the rainy season is the planting season/period. But the rains are not friendly to all the desired crops. The search for a tomato variety that will be high yielding and of good quality when planted during the rainy season is still the problem of many farmers. Dwarfgem variety is high yielding but possesses poor quality, although it can survive damping-off. This work is therefore designed to ascertain physiological manipulations that will improve the mineral constituents of the dwarfgem tomato variety through nutritional treatments. The study was carried out at Nnamdi Azikiwe University, Awka. Seeds of dwarfgem were obtained from Agricultural Development Program (ADP) Awka. Seeds were raised in the nursery. Twenty pieces of 40cm plastic buckets was used to prepare two groups of media according to the treatments which comprised of 14 buckets each filled with mixture of organic manure and soil at the standard rate of 640g/60kg (32g/hectare) while the remaining six buckets was filled with only soil. Organic manure was goat pellets while inorganic manure was NPK (15:15:15). Salinity, (NaCl), and Bicarbonate (H_3C0_3) were supplied at 2mM concentration in the irrigation water. The buckets were arranged according to treatments in a Randomized Completely Block Design (RCBD). Mineral was determined by standard method. Data were statistically analyzed using ANOVA and means were separated using computer modulated Duncan Multiple Range Test (Duncan, 1955). subjected to statistical analysis using Duncan T – test to separate the Means. The tomato plants treated with organic and inorganic fertilizers in combination with NaCl and BICA produced fruits with high levels of Na (600.41±0.015ppm), K (291.90±0.010ppm), Mg (148.50 ±0.010ppm) and Fe (3.46±0.010ppm) while the least was recorded in the control. The plants treated with organic and Nitrogen fertilizers in combination with NaCl and BICA also increased the tomato Cu content whereas the least was produced by fruits from the control. This has shown that the treatment of dwarfgem tomato variety with organic and inorganic fertilizer in combination with salinity and bicarbonate fully improved the fruit quality of the plant fruit mineral.

Keywords: Tomato, dwarfgem, mineral, bicabornate, organic manure, inorganic fertilizer,

INTRODUCTION

Tomato (Solanum lycopersicum) is one of the most popular and widely consumed important vegetable worldwide (Gandillo et al., 1999). They are used in many processed food products such as sauces, salads, soups, and pastes (Lenucci et al., 2006). Common nutrients reported to be present in tomatoes are vitamins, minerals, fiber, protein, essential amino acids, monounsaturated fatty acids, carotenoids and phytosterols (Elbadrawy and Sello, 2016; Abdullahi et al., 2016; Ramos-Bueno et al., 2017; Chaudhary et al., 2018). The combination of vitamins, minerals, amino acids, and fats all together contribute to making tomato part of a balanced diet. These nutrients perform various body functions including constipation prevention, reduction in high blood pressure, stimulation of blood circulation, maintenance of lipid profile and body fluids, detoxification of body toxins and maintaining bone structure as well as strength (Salehi et al., 2019; Campertrini et al., 2019).

Tomatoes are also an excellent source of bioactive compounds, commonly known as secondary metabolites, the concentrations of which are correlated with the prevention of human chronic degenerative diseases, such as cardiovascular disease (CVD), cancer, and neurodegenerative diseases (Cheng et al.,2019; Li et al., 2020; Park et al., 2020). Tomato is an important dietary source of both soluble and insoluble dietary fibers, namely cellulose, hemicelluloses and pectins (Claye et al., 1996). In general, these fibers are resistant to intestinal digestion in the large intestine and are believed to ameliorate bowel disorders, cancer, diabetes, CVDs, and obesity (Delzenne et al., 2020; Merenkova et al., 2020). Nutritional composition of tomato varies based on the tomato cultivar, extraction procedures, analysis methods and environmental conditions.

Nutrients when in adequate quantity, increases fruit quality, fruit size, colour, and fruit taste of tomato and also helps in increasing desirable acidic flavour (Azad, 2000). The use of organic manure alone is faced with problems of bulkiness and dirt. A balanced use of organic and inorganic fertilizers could enhance soil chemical, physical and biological properties as well as rate of nutrient turn over within the soil-plant system (Okwu, 2004).

Diseases and infestations are well known factors that decrease crop yields and expand production costs. Disease infestation is mostly controlled by using chemicals which occasionally reaches the level of toxicity. Currently, it is evident that improvement of tomato crop is a critical task that needs to overcome the constraint of tomato production. Damping off is a serious disease of tomato and other vegetables such as beans, okra, egg-plant and flowers with up to 30% yield loss (Badadoost and Islam, 2003: Bacharis et al., 2010; Horst, 2013). In light of the high economic impact of damping off and negative environmental effects generated by conventional fungicide-based control strategies, there is need to develop alternative and sustainable solutions to manage damping off. Nature has provided a great wealth of resistances that are available in the wild species and many of these resistances are simply inherited.

To increase the chances of fruit supply, human ancestors domesticated wild plant species into cultivated crops. It has been shown that a large genetic variation is present and exploitable from wild Solanum species but most of it is still untapped. These genetic variations present in the wild species have been investigated intensively for specific traits and it is being exploited in tomato breeding (Larry and Joanne, 2007).

Since the dwarfgem variety of the tomato is a well known type, that is naturally high yielding and is resistant to damping- off, but possess poor structural and nutritional qualities: this study was designed to ascertain the nutritional treatment that will improve the mineral composition of the dwarfgem tomato. This will help farmers to produce quality as well as high yielding tomato fruits even during the rainy season

MATERIALS AND METHODS

Study Area: This work was carried out at Nnamdi Azikiwe University, Awka, Anambra State. Anambra State is located in the south-eastern part of Nigeria and lies between latitudes 6º 13ʾ and 16ʾ N and longitude 7º 4ʾ and 7º 41ʾ E and Altitude 160.8m respectively (Ezenwaji et al., 2014; CLSI, 2008). The research is based on the influence of nutritional treatments on the mineral content of dwarfgem tomato variety (Solanum lycopersicum var dwarfgem L.).

Source of materials: Tomato seeds of the variety dwarf gem used for this experiment were procured from Agricultural Development Program (ADP) Awka, under special arrangement with an Extension officer with Awka South Local Government. In selecting for seed extraction, efforts were made to collect fruits from self-pollinated variety so as to maintain true to type. The seeds were extracted and washed thoroughly with tap water. The washed seeds were air dried under room temperature and stored in air tight plastic containers prior to use.

Plastic containers (40cm) were used and they were perforated below for easy drainage of water, a mesh (0.2mm-0.5mm) was cut and placed inside the bucket to hold the soil.

Prior to planting, the seeds were soaked in water for 3 hours to aid imbibition.

Nutritional chemicals were procured from Gepet Laboratory Chemicals and Equipment Ltd Onitsha in Anambra State. NPK fertilizer 15:15:15 was supplied by the Agricultural Development Programme (ADP) Awka. Farm yard manure (goat pellets) was obtained from a goat rearer at Enugwu-Ukwu in Anambra State.

Source of soil: The soil used for planting was excavated from an abandoned farmland within Nnamdi Azikiwe University, Awka.

Preparation of nursery: Four plastic containers measuring 48cm×28cm×20cm (L×B×H) were perforated below and filled with sandy- loam soil. The soil filled plastic containers were watered for four days before planting.

Planting and Germination: The seeds were planted by broadcast method; the broadcast seeds were covered with light layer of soil to encourage imbibition. The set-up was watered every 2 days, and continued till transplanting. This maintained the temperature of the soil within 20ºC and 24ºC, the standard temperature for optimum tomato seed germination (Garza and Molina, 2008).

Transplanting: A total of twenty plastic buckets were used for this experiment. Fourteen out of the twenty plastic buckets used were each filled with a mixture of soil and organic manure. This mixture of soil and organic manure was prepared at the rate of 30kg soil to 0.32kg/hectare organic manure. Six similar plastic buckets were also filled with 30kg of soil only. All the soil filled plastic buckets were watered daily for three days before transplanting.

Following germination of tomato seeds in the nursery, the seedlings were transplanted after 28 days of growth (28 DAP). Three plants were transplanted into each of the plastic buckets in the evening and watered day and night for 14 days to encourage stabilization**.** The plastic buckets were separated based on treatments and each group clearly identified in the field. Following stabilization, the three plants in each bucket were thinned down to two plants per bucket and their respective treatments were applied as in the design.

Treatment

Using randomized complete block design, the plastic buckets were separated into ten treatments which included the control. Each treatment comprised of two buckets.

The treatments were distributed as below;

1.Control

2.Organic

3.Inorganic

4.Organic + Inorganic

5.Organic + Salinity + Bicarbonate

6.Inorganic + Salinity + Bicarbonate

7.Organic +Inorganic+ Salinity + Bicarbonate

8.Organic + Nitrogen + Salinity + Bicarbonate

9.Organic + Phosphorus + Salinity + Bicarbonate

10.Organic + Potassium + Salinity + Bicarbonate

Plants which received inorganic fertilizer treatments were treated with the fertilizer NPK 15:15:15) using the ring method. The fertilizer was supplied at the rate of 5g per plant as a single dose fourteen days after transplanting (14 DAT) when the plants were already stabilized.

Farm yard manure (Goat pellets)

The 30kg of soil contained by each bucket used for organic manure treatments was incorporate with 0.32kg/hectare of organic manure. The manure was mixed with the soil and buckets were filled. Thereafter, the set-up was watered for 7 days to aid ammonification before plants were introduced.

Preparation of stock solutions

The following compounds were used to access improvement in the nutritional content of the plants. For each nutrient, 2mM concentration was prepared

i. For Nitrogen source: Sodium nitrate ($NaNO_3$)

ii. Phosphorus source: Sodium biphosphate

iii. Bicarbonate source: Potassium hydrogen carbonates (K_2HCO_3)

iv. Salinity: Sodium Chloride (Nacl)

v. Potassium source: Potassium nitrate (KNO_3)

First, 2M stock solution of each nutrient was prepared. From this, 2mM concentration of the required nutrition was prepared in 80 litres container of water for irrigation. The irrigation of plants commenced after fertilization of plants.

Control

Plastic buckets containing the control plants had only 30kg of soil.

Measurement

Fruits were harvested at 10 days interval for three consecutive times representing the initial, second and final harvests. Each assay or measurement was in triplicate and results were obtained as mean of three determinations

MINERAL ANALYSIS

Mineral analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA 1995 (American Public Health Association)

Principle:

Atomic Absorption Spectrometer principle is based on the sample being aspirated into the flame and then atomized when the AAS light is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element was used, making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame was proportional to the concentration of the element in the sample.

Sample digestion:

Two grams (2g) of the dried sample was weighed into a digestion flask and 20ml of acid mixture (650ml conc. HNO_3; 80ml perchloric acid; 20ml conc. H_2SO_4) was added.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

The flask was heated until a clear digest was obtained

The digest was diluted with distilled water to the100ml mark.

The sample was thoroughly mixed by shaking, and 100ml of it was transferred into a glass beaker of 250ml volume to which 5ml of conc. nitric acid was added and then

heated to boil till the volume was reduced to about 15-20ml, by adding conc. nitric acid in increments of 5ml till all the residue was completely dissolved. The mixture was cooled, transferred and made up to 100ml using metal-free distilled water. The sample was aspirated into the oxidizing air-acetylene flame. When the aqueous sample was aspirated, the sensitivity for 1% absorption was observed.

Preparation of reference solution:

A series of standard mineral solutions in the optimum concentration range were prepared, the reference solutions were prepared daily by diluting the single stock element solutions with water containing 1.5ml conc. nitric acid/liter. A calibration blank was prepared using all the reagents except for the metal stock solutions. Calibration curve for each metal was prepared by plotting the absorbance of the standard versus their concentrations

Data Analysis

Data were collected from each assay in triplicate and results obtained were expressed as means ± standard deviation. Means (of three determinations) ± standard deviation.Analysis of Variance (ANOVA) was used and Test of significance was further carried out using Duncan´s Multiple Range Test of (Duncan, 1955). The means were separated using Least significant Difference. Test of significance was conducted at 95% level of probability.

RESULTS AND DISCUSSION

Fruit Zinc Content

Analysis of the mineral content of the tomato fruits showed that Zinc gave the highest value of 3.14±0.001ppm, in the plant treated with organic fertilizer in combination with Nitrogen, Nacl and BICA. This was significantly higher than that obtained from other treatments. The least value of 0.97±0.001ppm was obtained from the fruits of the control plant ($P<0.003$). (Table 1)

Table 1: Zinc (Zn) composition of tomato fruits as influenced by Treatments

Treatments	Zinc Contents (ppm)
T1	0.97 ± 0.001^{j}
T2	1.66 ± 0.002^{e}
T3	1.17 ± 0.001^{i}
T4	1.88 ± 0.001^{b}
T5	1.34 ± 0.002^{g}
T6	1.25 ± 0.002^{h}
T7	1.70 ± 0.001^{c}

T8	3.14± 0.001[a]
T9	1.69 ± 0.001[d]
T10	1.65 ± 0.001[f]

*Values with different superscripts are significantly different (P<0.003)

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Calcium Content

Calcium content assay revealed that the tomato plant treated with organic fertilizer in combination with Nitrogen, Nacl and BICA gave the highest value of 150.10±0.021ppm. The value obtained from this treatment was significantly higher than that obtained from the other treatments. This value was followed by the one obtained from the plant treated with organic and inorganic fertilizers with a value of 124.40±0.020ppm. The control plant fruits gave the least calcium value, of 80.20±0.010ppm (P<0.029). (Table 2)

Table 2: Calcium (Ca) composition of tomato fruits as influenced by Treatments

Treatments	**Calcium Contents (ppm)**
T1	80.20 ± 0.010[j]
T2	116.40 ± 0.010[c]
T3	99.70 ± 0.020[h]
T4	124.40 ± 0.020[b]
T5	100.30 ± 0.010[g]
T6	98.80 ± 0.030[i]
T7	100.90 ± 0.010[f]
T8	150.10± 0.021[a]
T9	109.50 ± 0.010[e]
T10	112.20 ± 0.010[d]

*Values with different superscripts are significantly different (P<0.029).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Sodium Content

Sodium content assay of the fruit showed that the tomato plant treated with organic and inorganic fertilizers, in combination with Nacl and BICA gave the highest value of 600.41±0.015ppm. This value was followed by 514.30±0.020ppm, obtained by the plant grown with inorganic fertilizer in combination with Nacl and BICA. The control plants had the least sodium content of 424.20±0.015ppm (P>0.301). (Table 3)

Table 3: Sodium (Na) composition of tomato fruits as influenced by Treatments

Treatments	**Sodium Contents (ppm)**
T1	424.20 ± 0.015^{j}
T2	438.70 ± 0.010^{i}
T3	447.70 ± 0.010^{h}
T4	452.40 ± 0.015^{g}
T5	513.00 ± 0.020^{c}
T6	514.30 ± 0.020^{b}
T7	600.41 ± 0.015^{a}
T8	492.00 ± 0.000^{d}
T9	453.40 ± 0.010^{f}
T10	471.20 ± 0.017^{e}

*Values with different superscripts are significantly different (P>0.301).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Iron Content

Iron (Fe) content assay of the fruit revealed that the highest value of 3.46±0.001ppm, was obtained from the tomato plants treated with organic and inorganic fertilizers in combination with Nacl and BICA. This was followed by a value of 3.26±0.001ppm obtained from the plant grown with organic fertilizer in combination with Phosphorus, Nacl and BICA. The least value, 1.60±0.001ppm, was obtained from the plant fed with inorganic fertilizer (P<0.043). (Table 4).

Table 4: Iron (Fe) composition of tomato fruits as influenced by Treatments

Treatments	Iron Contents (ppm)
T1	1.94 ± 0.002^{i}
T2	2.47 ± 0.001^{f}
T3	1.60 ± 0.001^{j}
T4	2.73 ± 0.017^{e}
T5	1.96 ± 0.001^{h}
T6	2.23 ± 0.001^{g}
T7	3.46 ± 0.001^{a}
T8	2.90 ± 0.001^{c}
T9	3.26 ± 0.001^{b}
T10	2.82 ± 0.001^{d}

*Values with different superscripts are significantly different (P<0.043).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Magnesium Content

Magnesium (Mg) content of the tomato fruit showed that the plant fed with organic and inorganic fertilizers gave the highest value of 148.50±0.010ppm. This was followed by the value of 111.50±0.010ppm, from the plant grown with organic manure. The control gave the least value of 97.90±0.020ppm. Differences among the treatments were significant (P<0.000). (Table 5).

Table 5: Magnesium (Mg) composition of tomato fruits as influenced by Treatments

Treatments	Magnesium Contents (ppm)

T1	97.90 ± 0.020[h]
T2	111.40 ± 0.010[b]
T3	110.50 ± 0.010[c]
T4	148.50 ± 0.010[a]
T5	98.50 ± 0.020[g]
T6	87.70 ± 0.020[i]
T7	110.40 ± 0.020[d]
T8	105.60± 0.010[e]
T9	98.50 ± 0.010[g]
T10	99.33 ± 0.042[f]

*Values with different superscripts are significantly different (P<0.000).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Phosphorus Content

The fruit Phosphorus content revealed that the plant treated with organic manure in combination with Phosphorus, Nacl and BICA, gave the highest value of 275.90±0.010ppm. The value, 265.50±0.020ppm was obtained from the plant grown with organic and inorganic fertilizers. The least value, 234.80±0.010ppm was obtained from the plant fed with organic fertilizer in combination with Nacl and BICA (P>0.977). (Table 6)

Table 6: Phosphorus (P) composition of tomato fruits as influenced by Treatments

Treatments	Phosphorus Contents (ppm)
T1	241.10 ± 0.020[h]
T2	251.10 ± 0.000[e]
T3	249.40 ± 0.020[g]
T4 T5	265.50 ± 0.020[b] 234.80 ± 0.010[j]
T6	236.10 ± 0.000[i]

T7	250.40 ± 0.017[f]
T8	263.90± 0.010[c]
T9	275.90± 0.010[a]
T10	260.10 ± 0.010[d]

*Values with different superscripts are significantly different (P>0.977).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Potassium Content

The fruit Potassium content was observed to have the highest value (291.90±0.010ppm) in the plants grown with organic and inorganic fertilizers. However, the differences between that and the potassium content of those fruits whose plants were treated with organic and inorganic fertilizers. in combination with Nacl and BICA and organic fertilizer in combination with Potassium, Nacl and BICA were not significant. The least value of 222.40±0.010ppm was obtained from the plant supplied with inorganic fertilizer, Nacl and BICA combination (P>0.144). (Table 7)

Table 7: Potassium (K) composition of tomato fruits as influenced by Treatments

Treatments	**Potassium Contents (ppm)**
T1	232.60 ± 0.010[e]
T2	277.00 ± 0.000[b]
T3	240.30 ± 0.188[d]
T4	291.90 ± 0.010[a]
T5	239.10 ± 0.020[d]
T6	222.40 ± 0.010[f]
T7	290.40 ± 0.017[a]
T8	239.40± 0.010[d]
T9	245.20 ± 0.010[c]
T10	289.10 ± 0.010[a]

*Values with different superscripts are significantly different (P>0.144)

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Cupper Content

Copper (Cu) content of the fruit of tomato indicated that the tomato plants supplied with organic and inorganic fertilizers gave the highest value of 0.99±0.001ppm. This was followed by a value of 0.98±0.001ppm, obtained from the plants fed with inorganic fertilizer, Nacl and BICA combination. The least value of 0.43±0.001ppm was obtained from the plants grown with organic fertilizer, Potassium, Nacl and BICA combinations (P>0.093). (Table 8).

Table 8: Copper (Cu) composition of tomato fruits as influenced by Treatments

Treatments	**Cupper Contents (ppm)**
T1	0.48 ± 0.002^{gh}
T2	0.56 ± 0.002^{e}
T3	0.96 ± 0.001^{c}
T4	0.99 ± 0.001^{a}
T5	0.48 ± 0.002^{g}
T6	0.98 ± 0.001^{b}
T7	0.60 ± 0.001^{d}
T8	0.55 ± 0.001^{f}
T9	0.45 ± 0.001^{i}
T10	0.43 ± 0.001^{j}

*Values with different superscripts are significantly different (P>0.093)

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Fruit Molybdenum Content

Molybdenum (Mo) content of the tomato fruit showed that the highest value of 0.96±0.001ppm, was obtained from the tomato plants supplied with organic and inorganic fertilizers in combination with Nacl and BICA. The least value of 0.05±0.000ppm was attained from the plants treated with organic fertilizer, Phosphorus, Nacl and BICA (P<0.000). (Table 9).

Table 9: Molybdenum (Mo) composition of tomato fruits as influenced by Treatments

Treatments	**Molybdenum Contents (ppm)**
T1	0.05 ± 0.002^{g}
T2	0.11 ± 0.001^{c}
T3	0.12 ± 0.001^{b}
T4	0.12 ± 0.017^{b}
T5	0.08 ± 0.001^{de}
T6	0.08 ± 0.001^{d}
T7	0.96 ± 0.001^{a}
T8	0.06 ± 0.001^{f}
T9	0.05 ± 0.001^{g}
T10	0.05 ± 0.001^{g}

*Values with different superscripts are significantly different (P<0.000).

Where;

T1=Control T2 = organic

T3 = inorganic T4= organic/inorganic

T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA

T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA

T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

DISCUSSION

The above results indicated enhancement in fruit quality and in mineral composition of fruit as Mg and Cu contents were highest in the tomato fruit treated with organic and inorganic fertilizers. Iron was highest in the fruit treated with inorganic fertilizer in combination with Nacl and BICA while Na and Mo were highest in the plants grown with organic and inorganic fertilizers in combination with Nacl and BICA. These results are in agreement with the work of Zeid et al. (2015), who observed that inorganic doses of NPK application in combination with organic materials stimulated the accumulation of nutrient elements in both leaves and tubers of radish plants as compared with inorganic fertilizer alone. This might be due to the synergistic effect between inorganic fertilizers and organic materials for increasing soil available macro and micro nutrient status. The results indicated the importance of the conjunctive use of organic and inorganic fertilizer for creating proper condition to get the maximum benefit of the native elements.

The promotion of Zn and Ca contents by organic fertilizer in combination with Nitrogen, NaCl and BICA may be in line with the availability of these applied nutrients to the plant within the rhizosphere. These substances cannot antagonize each other, thereby, allowing the plant to take them up for maximum utilization.

The highest improvement of tomato fruit Sodium, Iron and Magnesium contents by organic and inorganic fertilizer in combination of Nacl and BICA may be as a result of a balance created by organic and inorganic fertilizer as well as Nacl and BICA such that these minerals which are favoured by alkalinity were synthesized by plants when their environments are favourable through nutritional supply (Dutta, 2003).

Phosphorus, Potassium and Copper compositions were strongly promoted by treatments involving organic and inorganic fertilizer even in the presence of Nacl and BICA. This clearly shows the ability of plants to allocate photosynthates directly as synthesis progresses. The supply of both organic and inorganic fertilizer shows a condition similar to full strength nutrient solution which would allow plants to absorb maximum nutrient need and allocate the products to the desired plant part (Izundu et al., 2011a). In this case, the fruit took the highest allocation.

The promotion of highest Molybdenum content in tomato fruits of the plants treated with organic manure, Nacl and BICA is in line with the reports of Izundu et al. (20…….). They explained that the molybdoenzymes are activated/induced by Nacl and BICA thereby, increasing molybdenum pool in the tomato fruit.

Mofunanya et al. (2015) reported that organic fertilizer produced higher mineral composition of Zn, Cu, Mg, k, Fe, Ca, Na assnd P in Amaranthus spinosus than inorganic fertilizer in all the plant samples studied. Zn, Ca, and N were highest in the tomato treated with organic fertilizer in combination with Nitrogen, Nacl and BICA. For P and K, their highest values were in the plants treated with organic fertilizer in combination with Phosphorus, Nacl and BICA and organic fertilizer in combination with Potassium, Nacl and BICA respectively. These results are in line with those reported

Although Nacl treatment induces stress such as its Cl^- interference with No_3^- flux into roots, introduction of HCO_3^- (bicarbonate) improved Nacl treated plants incorporation of nutrients especially when other nutrients as organic and inorganic fertilizers are available. This is corroborated by the result of this research where treatments in combination with Nacl and BICA accumulated higher minerals. Thomas and Langdale (1980) had reported that increased nitrate fertilization in the medium improved growth of Nacl- treated plants more than plants without Nacl treatment.

The general increase in fruit mineral contents as a result of organic manures application in combinations with inorganic fertilizer and other mineral nutrition might be due to the enhancement of soil properties and soil fertility by organic soil amendments (Kaur et al 2005) which might lead to increased available nutrients and their uptake (Kanal and Kuldkepp, 1993). Moreover similar increase in fruit mineral contents by organic manures alone or in combination with mineral source were obtained by Attala et al. (2003) working on Samany and Zaghloul date cultivars.

CONCLUSION

The present research has been able to show that nutritional treatment in form of organic and inorganic fertilizer in combination with salinity and bicarbonate totally improved the fruit quality of dwarfgem tomato. The mineral content of dwarfgem tomato were variously improved to a level that presents this tomato variety as desired for quality tomato production. Although Nacl affects the transport pathways of plants, the combination with BICA ameliorates its uptake and even allows nutrient reduction in the root. Hence the plant treated with both nutrients have two points of reduction viz, the root and the leaf, This means that in the translocation of materials up the plant, reduced substances like amides are moved to prioritized parts for quick incorporation. Treatment of plants with both organic and inorganic fertilizer and the increased zone of nutrient allocation through introduction of Nacl and BICA has provided farmers a solution on how to satisfy consumers of tomato even during the rainy season by applying the physiological manipulation to dwarfgem variety

REFERENCES

1. Abdullahi I.I., Abdullahi N., Abdu A.M., Ibrahim A.S. Proximate, Mineral and Vitamin Analysis of Fresh and Canned Tomato. Biosci. Biotechnol. Res. Asia. 2016;13:1163–1169.
2. Attala, H.A., Shahein, H.A., Kassem, S. Hoda and Aly, S.H. (2003). Effect of applying different organic and inorganic nitrogen sources to Zaghloul and Sammmmany date cultivars on : I. leaf and fruit mineral content. Proceedings of the International Conference on Date Palm, 16-19 Sept 2003, College of Agric and Vet. Med., King Saud Univ., Qassem Branch, Kingdom of Saudi Arabia, pp. 209 – 222.
3. Aurand L.W. (2013). Food Composition and Analysis. Springer; Dordrecht, The Netherlands.
4. Azad, A. K. (2000). Effects of plant spacing, source of nutrients and mulching on growth and yield of cabbage. M. Sc. Thesis. Department of Horticulture, Bangladesh Agriculture University Mymensingh, pp. 15-40
5. Bacharis C, Gouziotis A, Kalogeropoulou P. (2010). Characterization of Rhizoctoniaspp. Isolates associated with damping-off disease in cotton and tobacco seedlings in Greece. Plant Discovery,**94**:1314-1332.
6. Badadoost, M. and Islam, S.Z. (2003). Fungicide seed treatment effects on seedling damping-off of pumpkin caused by Phytophthora capsici. Plant Discovery, **87**:63-68.
7. Campestrini, L.H., Melo P.S., Peres L.E.P., Calhelha R.C., Ferreira I.C., De Alencar S.M. (2019). A new variety of purple tomato as a rich source of bioactive carotenoids and its potential health benefits. Heliyon. 5:e02831. doi: 10.1016/j.heliyon.2019.e02831.
8. Chaudhary P., Sharma A., Singh B., Nagpal A.K. Bioactivities of phytochemicals present in tomato. J. Food Sci. Technol. 2018;55:2833–2849.
9. Cheng H.M., Koutsidis G., Lodge J.K., Ashor A.W., Siervo M., Lara J (2019). Lycopene and tomato and risk of cardiovascular diseases: A systematic review and meta-analysis of epidemiological evidence. Crit. Rev. Food Sci. Nutr. **59**:141–158.]
10. Claye S.S., Idouraine A., Weber C.W. Extraction and fractionation of insoluble fiber from five fiber sources. Food Chem. 1996;57:305–310. doi: 10.1016/0308-8146(95)00250-2.
11. Clinical Laboratory Standards Institute CLSI Document M38-42. Wayne , PA: Clinical Laboratory Standards Institute. Reference Method for Broth Dilution Antifungal Susceptibility Testing of Filamentous Fungi; Approved Standard – Second Edition;; 2008.
12. Delzenne N.M., Olivares M., Neyrinck A.M., Beaumont M., Larsen T.M., Benitez-Paez A., Romani-Perez M., Garcia-Campayo V., Bosscher D., Sanz Y., et al. Nutritional interest of dietary fiber and prebiotics in obesity: Lessons from the MyNewGut consortium. Clin. Nutr. 2020;39:414–424.
13. Domínguez, R., Gullón, P., Pateiro, M., Munekata, P.E.S., Zhang, W. and Lorenzo, J.M. (2020). Tomato as Potential Source of Natural Additives for Meat Industry. A Review. Antioxidants. 9:73.
14. Duncan, D.B. (1955). Multiple Range and Multiple F-Test. Biometrics, 11:1-5.
15. Dutta, A.C. (2003). Botany for Degree students. **6th Edn.,** Oxford University Press, New Delhi, India, pp. 301-588.
16. Elbadrawy E., Sello A. Evaluation of nutritional value and antioxidant activity of tomato peel extracts. Arab. J. Chem. 2016;9:S1010–S1018.
17. Ezenwaji, E.E., Otti, V.I. and Ezenwaji, I.O. (2014). Spatial Patterns of Residential Water Supply Accessibility Levels in Anambra State, Nigeria. Journal of Water Resource and Protection, 6(7):
18. Gandillo, S., Zamir, D. and Tanksley, S. D. (1999). Genetic improvement of processing tomatoes. A 20 years perspective. Euphytica, **110**:85-97.
19. Garza, M. and Molina, M. (2008),"Manual para la Produccion de Tomate en Invernadero en Suelo en el Estado de Nuevo Leon, SAGAPRA
20. Harris, G.K., and Marshall, M.R. (2017). Food Analysis. Springer; Cham, Switzerland: 2017. Ash analysis; pp. 287–297.
21. Horst, R.K. (2013).Damping-off. Westcott's plant disease handbook. Springer Netherlands, Dordrechtr, pp 177.

22. Imran M., Ghorat F., Ul-Haq I., Ur-Rehman H., Aslam F., Heydari M., Shariati M.A., Okuskhanova E., Yessimbekov Z., Thiruvengadam M., et al. Lycopene as a natural antioxidant used to prevent human health disorders. Antioxidants. 2020;9:706.
23. Izundu, A.I., Lips, S.H. and Nwanna, I.E. (2011a). Effects of Bicarbonate fertilization on tomato fruit yield and quality. International Journal of Biological Sciences, 3(3):134-143.
24. Izundu, A.I., Okafor, E.U. and Lips, S.H. (2011b). Effects of Nacl, salinity and increasing inorganic carbon fixation carbon partitioning. Journal of Science Engineering and Technology,18(3):10413-10425.
25. Kanal, A. and Kuldepp, P. (1993). Direct and residual effect of different organic fertilizers on potato and cereals. J. Agron. Crop Sci., 171:185 – 195.
26. Kaur, K., kapoor, K.K. and Gupta, A.P. (2005). Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. 168: 117 – 122.
27. Kelebek H., Selli S., Kadiroğlu P., Kola O., Kesen S., Uçar B., Çetiner B. Bioactive compounds and antioxidant potential in tomato pastes as affected by hot and cold break process. Food Chem. 2017;220:31–41. doi: 10.1016/j.foodchem.2016.09.190.
28. Larry, R. and Joanne, L. (2007). Genetic resources of tomato. In:Razdan M. K. and Mattoo, A. K. editors. Genetic improvement of solanaceous crops. **Vol. 2**. Enfield, NH: Science Publishers; Tomato.
29. Larry, R. and Joanne, L. (2007). Genetic resources of tomato. In:Razdan M. K. and Mattoo, A. K. editors. Genetic improvement of solanaceous crops. **Vol. 2**. Enfield, NH: Science Publishers; Tomato.Zhu, J. K. (2001). Plant salt tolerance. Trends in Plant Science. **6**:66-71.
30. Lenucci, M.S., Cadinu D., Taurino M., Piro G., Dalessandro G. Antioxidant composition in cherry and high-pigment tomato cultivars. J. Agric. Food Chem. 2006;54:2606–2613. doi: 10.1021/jf052920c
31. Li N., Wu X., Zhuang W., Xia L., Chen Y., Wu C., Rao Z., Du L., Zhao R. and Yi M. (2020) Tomato and lycopene and multiple health outcomes: Umbrella review. Food Chem. :128396. doi: 10.1016/j. foodchem.2020.128396.
32. Lu, Z., Wang, J., Gao, R., Ye, F. and Zhao, G. (2019). Sustainable valorisation of tomato pomace: A comprehensive review. Trends Food Sci. Technol., 86:172–187.
33. Maestri, D., Barrionuevo, D., Bodoira, R., Zafra, A., Jiménez-López, J.C. and Alché, J.D.D. (2019). Nutritional profile and nutraceutical components of olive (Olea europaea L.) seeds. J. Food Sci. Technol. 56:4359–4370.
34. Merenkova S., Zinina O., Stuart M., Okuskhanova E., Androsova N. Effects of dietary fiber on human health: A review. Человек. Спорт. Медицина. 2020;20:106–113. doi: 10.14529/hsm200113.
35. Mofunanya, A.A.J., Ebigwai, J.K., Bello, O.S. and Egbe, A.O. (2015). Comparative study of the effects of organic and inorganic fertilizer on the Nutritional composition of Amaranthus spinosus L. Asian Journal of Plant Sciences, **14**:34-39.
36. Muir, J. G., Rose, R. and Rosella, O. (2009). Measurement of short-chain carbohydrates incommon australian vegetables and fruits by high-performance liquid chromatography (HPLC). Journal of Agriculture and Food Chemistry. **57**:554-565.
37. Nielsen S. S. (2010). Food Analysis Laboratory Manual. Springer; Boston, MA, USA. Determination of moisture content; pp. 17–27.
38. Okwu, D.E. (2004). Evaluation of the chemical composition of indigenous species and flavoring agents. Journal of Sustainable Agriculture Environment, **6**:30-45
39. Park H.-A., Hayden M.M., Bannerman S., Jansen J. and Crowe-White K.M (2020). Anti-apoptotic effects of carotenoids in neurodegeneration. Molecules **25**:3453. doi: 10.3390/molecules25153453.
40. Paulino, S.L.J., Adrián, Á.-T.G., Gabriela, E.-A.L., Maribe,l V.-M. and Sergio, M.-G. (2020). Nutraceutical potential of flours from tomato by-product and tomato field waste. J. Food Sci. Technol. ,57:3525–3531.
41. Phizicky, E., Bastiaens, P.I.H., Zhu, H. and Snyder M. and Fields, S. (2003). Protein analysis on a proteomic scale. Nature, 422:208–215.
42. Pomeranz, Y. (2013). Food Analysis: Theory and Practice. Springer; Boston, MA, USA.
43. Ramdath, D.D., Lu, Z.-H., Maharaj P.L., Winberg, J., Brummer, Y. and Hawke, A. (2020). Proximate Analysis and Nutritional Evaluation of Twenty Canadian Lentils by Principal Component and Cluster Analyses. Foods. 2020;9:175

44. Ramos-Bueno R.P., Romero-Gonzalez R., Gonzalez-Fernandes M.J., Guil-Guerrero J.L. Phytochemical composition and in vitro anti-tumour activities of selected tomato varieties. J. Sci. Food Agric. 2017;97:488–496.
45. Salehi B., Sharifi-Rad R., Sharopov F., Namiesnik J., Roointan A., Kamle M., Kumar P., Martins N., Sharifi-Rad J. (2019) Beneficial effects and potential risks of tomato consumption for human health: An overview. Nutrition. 62:201–208.
46. Sofy, A.R., Dawoud, R.A., Sofy, M.R., Mohamed, H.I., Hmed, A.A. and El-Dougdoug N.K. (2020). Improving regulation of enzymatic and non-enzymatic antioxidants and stress-related gene stimulation in cucumber mosaic cucumovirus-infected cucumber plants treated with glycine betaine, chitosan and combination. Molecules. 25:2341
47. Thomas, J.R. and Langdale, G.W. (1980). Ionic balance in coastal bermudagrass influenced by nitrogen fertilization and soil salinity. Agronomy Journal, **72**: 449 – 452.
48. Vats, S., Bansal R., Rana N., Kumawat S., Bhatt V., Jadhav P., Kale V., Sathe A., Sonah H., Jugdaohsingh R., et al. Unexplored nutritive potential of tomato to combat global malnutrition. Crit. Rev. Food Sci. Nutr. 2020:1–32.
49. Zeid, H.A., Wafaa, H.M., Abou El Seoud, I.I. and Alhadad, W.A.A. (2015). Effect of organic materials and inorganicfertilizers on the growth, mineral composition and soil fertility of Radish plants (Raphine´ssativus) grown in sandy soil. Middle East Journal of Agriculture Research, **4**: 77-87.
50. Zhu, J. K. (2001). Plant salt tolerance. Trends in Plant Science. **6**:66-71.