Original Research Article: full paper

(2024), «EUREKA: Life Sciences»
Number 1

# EVALUATION OF FERTILIZER TYPE AND RATE OF APPLICATION ON TOMATO FRUIT QUALITY

***Obey A. Zingwari***
*Department of Engineering and Physics*[1]

***Willard Zendera***
*Department of Agricultural Engineering and Technology*
*Manicaland State University of Applied Science*
*Stair Guthrie Road, P Bag 7001 Fernhill, Mutare, Zimbabwe, 00263*

***Freddy Masoso***
*Department of Engineering and Physics*[1]

***Taurira Mtaita***
*Department of Agricultural Sciences*
*College of Health, Agriculture and Natural Resources*
*P.O. Box 1320, Old Mutare, Zimbabwe, 00263*

***Moses Mutetwa***✉
*Department of Agronomy and Horticulture*
*Midlands State University*
*P. Bag 9055, Gweru, Zimbabwe, 00263*
*mosleymtetwa@gmail.com*

[1]*Bindura University of Science Education*
*741 Chimurenga Road Off Trojan Road, Bindura, Zimbabwe, 00263*

✉**Corresponding author**

**Summary**

Growing vegetables is seen as a promising method for ensuring sustainable food and nutrition security in the tropics. The rise in demand for tomatoes in this region has influenced production practices and strategies to meet local and export needs. Many tropical countries have expanded their tomato cultivation to fulfill local demand and potentially generate income from exports, as they have become increasingly important for food and nutrition security. Various successful production systems have been implemented around the world to grow tomatoes. However, Zimbabwean farmers are experiencing decreased yields and shorter shelf lives of tomatoes due to insufficient use of calcium, despite the pivotal role agrochemicals have played in boosting global agricultural production. This study aimed to assess the impact of different types and levels of basal chemical fertilizers on tomato quality. The three types of basal fertilizers used were Compound D [7:14:7], Gypsum, and a combination of both in equal proportions. These fertilizers were applied at rates of 50, 100, and 200 kg/ha. A Randomized Complete Block Design (RCBD) with four replications was utilized for the study. Tomato quality parameters such as ripe fruit count, size, disease prevalence, firmness, total soluble solids, weight loss, and shelf-life were measured. The results revealed significant differences ($p<0.05$) between the application rates and types of basal chemical fertilizers. The combination of Compound D and Gypsum had the most noTable effect, as the addition of calcium and sulfur improved the quality of tomato fruits. Ultimately, it was concluded that the best tomato quality was achieved when using a combination of Compound *D* and Gypsum at a rate of 200 kg/ha. These findings highlight the urgent need to promote the use of gypsum in tomato production.

**Keywords**: tomato, calcium, fruit quality, chemical fertilizer, productivity, profitability, eco-friendly, postharvest.

**DOI: 10.21303/2504-5695.2024.003327**

## 1. Introduction

One of the most widely used and essential vegeTable crops is tomato (*Solanum lycopersicun* L.) [1], making it the world's second most important vegeTable after potato [2, 3]. Its cultivation has significantly increased in popularity in the last 50 years [4]. With a global production of 182.0 million tons and 4.8 million hectares of production, tomatoes are economically significant [5]. The leading producers of tomatoes are China with 59.5 million tons, India with 20.7 million tons, and Zimbabwe with 26,619 tons.

Tomato cultivation is a major source of income for people in developing countries [6]. Tomatoes and tomato-based products are recommended as part of a healthy diet due to their low fat and calorie content, zero cholesterol, high fiber, and protein [7]. Furthermore, the nutritional quality of tomatoes is critical to consumers globally. Fresh tomato fruits are commonly eaten in sandwiches or salads as salsa, while processed forms are consumed in soups, sauces, drinks, juices, pastes, and preserves [8, 9].

As a climacteric fruit, tomatoes have a short shelf life and are prone to spoilage if not stored properly [10]. The conventional use of chemical fertilizers such as potash, superphosphate, and urea are widespread in agriculture. However, continuous use of these fertilizers can degrade soil fertility and characteristics, leading to the accumulation of heavy metals in plant tissues. This not only compromises the nutritional value and quality of the fruit, but also makes them more susceptible to disease and pest attacks [11, 12].

While agrochemicals have played a crucial role in increasing global agricultural production, Zimbabwean farmers are facing lower tomato yields and shorter shelf lives due to inadequate use of calcium. Many farmers have relied on Windmill compounds *S* [7:21:7:9] and compound D [7:14:7] as basal fertilizers for tomato planting, but these do not provide the necessary levels of calcium. This element is vital for the structure of primary cell walls, as it binds the pectate matrix in the middle lamella and strengthens plant tissue [13, 14]. The bonds formed are highly resistant to breakdown by enzymes such as polyglacturonase [15]. Additionally, the amount of Ca pectate present in the cell wall influences susceptibility to bacterial and fungal infections, as well as the ripening process of fruits. A lack of calcium can also lead to substrate leakage into the cytoplasm, resulting in increased respiration rates [16] and ultimately, plant tissue senescence.

Leaving the apoplast with low levels of free calcium can have detrimental effects on membrane integrity and structure, leading to membranes that are prone to leakage [17]. The deficiency of calcium can result in degeneration of the membrane and loss of cellular compartmentalization [15, 18]. Additionally, calcium plays a crucial role in enhancing the quality of tomatoes by increasing firmness, postponing ripening, minimizing physiological disorders, and prolonging shelf life [19]. Therefore, it is essential to ensure a balanced supply of nutrients, specifically calcium, for optimal yield and quality of fruits [20]. Research has shown that providing an ample supply of calcium through basal fertilization and foliar application leads to a higher production of markeTable fruits, longer shelf life, and larger fruits.

By effectively managing and utilizing calcium-rich fertilizers, such as Gypsum, farmers may be able to improve both the yield and quality of their tomatoes. The aim of this study was to investigate the impact of fertilizer type and application rate on tomato production.

## 2. Materials and methods

### 2. 1. Site and Plant material

The experiment was carried out in the Chivi District of Zimbabwe's Natural Region IV. The location is defined by calcimophic order vertisol soils generated from basalt rocks [21]. These soils are unleached and have a high concentration of weathered mineral reserves. The region is semi-arid, with annual rainfall of less than 400 mm and temperatures ranging from 28 °C to 30 °C on average.

### 2. 2. Experimental procedure

The samples were physiochemically analyzed at Chinhoyi University of Technology. The experiment was set up as a 3x3 factorial with a control treatment in Randomized Complete Block Design and replicated four times. The first factor was fertilizer type, with three treatment levels: Compound D (7 percent N, 14 % $P_20_5$, 8 % $K_20$), Gypsum ($CaSO_4.2H_20$, 23 % Ca, and 19 % Sulphur), and Compound D+Gypsum combination at 1:1 ratio. The second factor was fertilizer application rate, which had three treatment levels: 50, 100, and 200 kg $ha^{-1}$.

The experimental plot was 7.5 $m^2$ in size, with three rows (each 3 m long and 80 cm wide) and 30 cm between plants. The standard cultural practices for tomato production, such as irrigation, topdressing fertilizer, and pest control, were followed, and all treatment fertilizer application was done at planting. Throughout the experiment, the plots were kept weed-free. To prevent fungal diseases, Copper Oxychloride 50 percent was applied at ten-day intervals @ 2 kg $ha^{-1}$ active ingredient up to the reproductive stage. Dimethoate was also sprayed every two weeks to protect against sucking and leaf-eating insect pests. Dimathoate was applied at a rate of 75 ml per 100 liters of water per hectare. All other general tomato agronomic practices remained unchanged. Irrigation was also used to supplement the rain, and the plots were kept moist.

### 2. 3. Data collection

Data collection was done on the following parameters at 18 weeks after transplanting.

Numbers of ripened fruits: Ripe fruits ranged from the pink stage to the full red color of tomatoes.

Numbers of fruits with blossom end rot: The number of fruits with blossom end rot in each plot was recorded.

Fruit size (diameter): After each harvesting, ten fruits were chosen at random from each treatment. Fruit diameter was measured using a veneer caliper. As a result, an average was calculated.

Firmness: Ten fruits from each treatment were chosen at random. The firmness of the fruits was measured using a penetrometer Model SN 74078 Q A supplies, Holland with a 1.1 mm diameter. The firmness was measured in kilograms. The readings were taken from all ten fruits, and an average was calculated for each treatment.

Total soluble solids (TSS): The fruit juice was extracted and placed in a beaker, where TSS was determined using a hand-held refractometer (MA 871 NIEWKOOP BV). First, the refractometer was calibrated using distilled water and 0.02 percent sucrose. Two drops of each sample were placed in the refractometer, and readings were taken for ten samples, yielding an average per treatment.

Shelf life: Shelf life was calculated as the time (days) elapsed between:

1) harvest and fruit beginning to wrinkle;
2) harvest and watery fruit.

The harvested ripe fruits were placed on a clean table in a storeroom at room temperature, with the changes being closely monitored on a daily basis.

Weight loss: Ten fruit samples were collected from each plot. The samples were kept in the lab for 10 days at room temperature. The weight loss of fruit samples was measured every two days with a sensitive digital scale and expressed as a percentage using the formula below:

$$\textit{Weight loss}=[(\text{Final weight}-\text{initial weight})/\text{Initial weight}]\times 100. \quad (1)$$

### 2. 4. Data analysis

GenStat (version 14th) software was used to perform statistical Analysis of Variance (ANOVA) on all data. The Least Significant Difference (LSD) test at a 5 % level was used to determine mean differences, as described by Gomez and Gomez (1984).

## 3. Results

### 3. 1. Number of ripe fruits

The data in Table 1 clearly show that the application of chemical fertilizers had a direct influence on fruit ripening. The type of basal chemical fertilizers used had a significant ($p<0.001$) effect on tomato fruit ripening. The combination of Compound D+Gypsum produced the most ripened fruits, while Gypsum alone produced the fewest ripe fruits. Furthermore, the amount of chemical fertilizer applied varied according to the number of ripened fruits. The influence of chemical fertilizer on the number of ripened fruits increased as the level of fertilizer increased. The most effective treatment in terms of chemical fertilizer application was 200 kg $ha^{-1}$ The control treatment produced the fewest number of ripened fruits.

### 3. 2. Fruit size

As shown in **Table 1**, the use of a basal chemical fertilizer increased tomato fruit size significantly ($p<0.001$) when compared to the control treatments that did not use a basal chemical fertilizer.

When combined with Gypsum chemical fertilizer, the effect of Compound D chemical fertilizer was enhanced. Otherwise, increasing the Ca and S levels in the N-P-K in Compound D chemical fertilizer resulted in an increase in tomato fruit size. The amount of chemical fertilizer applied had a positive effect on fruit size, with an application rate of 200 kg $ha^{-1}$ producing the largest fruit size.

### 3. 3. Diseased fruits

As shown in **Table 1**, treatments with chemical fertilizers increased the number of diseased fruits significantly ($p<0.05$) more than the control treatment. The use of Compound *D* alone resulted in the greatest number of diseased fruits. However, combining Compound *D* with Gypsum resulted in a statistically ($p<0.001$) lower number of diseased fruits than using Compound D chemical fertilizer alone. A higher application rate of chemical fertilizer resulted in a significantly ($p<0.001$) lower number of diseased tomato fruits than a lower application rate treatment.

### 3. 4. Fruit firmness

Fruit firmness differed statistically ($p<0.05$) between treatments that used chemical fertilizer and the control treatment that did not. In terms of the effect of the type of basal chemical fertilizer used, Compound D had the lowest fruit firmness, while a combination of Compound D+Gypsum and Gypsum chemical fertilizer treatments did not differ statistically. The rate of chemical fertilizer application had a significant ($p<0.001$) effect on fruit firmness, which increased as the rate of chemical fertilizer application increased.

### 3. 5. Fruit TSS

The results for fruit TSS in **Table 1** show that treatments with basal chemical fertilizers statistically ($p<0.05$) gave lower fruit TSS than the control treatment. The effect of the type of basal chemical fertilizer used differed, with Compound D providing the highest fruit TSS while Gypsum and a combination of Compound D+Gypsum were not significantly ($p>0.05$) different. The application of 200 kg $ha^{-1}$ basal chemical fertilizer resulted in significantly ($p<0.001$) lower fruit TSS, whereas treatment application rate of 50 kg $ha^{-1}$ resulted in the highest fruit TSS. A base chemical application rate of 100 kg $ha^{-1}$ was no different than a rate of 50 kg $ha^{-1}$.

**Table 1**

Tomato fruit characters as influenced by application of chemical fertilizers at varying rates

| Treatments | Parameter | | | | |
|---|---|---|---|---|---|
| | Number of ripe fruits | Fruit diameter (cm) | Number of diseased fruits | Fruit firmness (N $mm^{-1}$) | Fruit TSS (°Brix) |
| **Effects of Fertilizer** | | | | | |
| Fertilized | $59.73^{b}$ | $3.511^{b}$ | $35667^{b}$ | $1.991^{b}$ | $6.812^{a}$ |
| Control | $50.22^{a}$ | $2.115^{a}$ | $17963^{a}$ | $1.533^{a}$ | $7.325^{b}$ |
| P-value | <0.001 | <0.001 | 0.001 | 0.016 | 0.003 |
| $LSD_{0.05}$ | 4.460 | 0.3144 | 3971.1 | 0.3674 | 0.1265 |
| **Effects of type of Fertilizer** | | | | | |
| Compound D | $59.46^{b}$ | $3.475^{b}$ | $21889^{b}$ | $1.628^{a}$ | $7.303^{b}$ |
| Gypsum | $55.52^{a}$ | $3.133^{a}$ | $16778^{a}$ | $2.110^{b}$ | $6.550^{a}$ |
| Compound D+Gypsum | $64.21^{c}$ | $3.925^{c}$ | $15222^{a}$ | $2.235^{b}$ | $6.667^{a}$ |
| P-value | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| $LSD_{0.05}$ | 3.455 | 0.2435 | 3076.0 | 0.2846 | 0.2282 |
| **Effects of the amount of fertilizer** | | | | | |
| 50 kg $ha^{-1}$ | $52.87^{a}$ | $2.150^{a}$ | $35778^{c}$ | $1.577^{a}$ | $7.275^{b}$ |
| 100 kg $ha^{-1}$ | $60.28^{b}$ | $3.258^{b}$ | $11333^{b}$ | $1.718^{a}$ | $7.118^{b}$ |
| 200 kg $ha^{-1}$ | $66.04^{c}$ | $5.125^{c}$ | $6778^{a}$ | $2.678^{b}$ | $6.227^{a}$ |
| P-value | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| $LSD_{0.05}$ | 3.455 | 0.2435 | 3076.0 | 0.2846 | 0.2282 |

*Note: Figures not sharing a common letter in a column differ significantly at 0.05 probability.*

### 3. 6. Days to wrinkle

**Fig. 1** depicts data pertaining to the number of days to fruit showing wrinkles. The type of basal chemical fertilizer used had a significant ($p<0.001$) effect. The use of Compound D+Gypsum chemical fertilizer resulted in fruits that took a long time to wrinkle. Wrinkles appeared the quickest after treatment with Compound *D* chemical fertilizer alone. The chemical fertilizer application rate had a significant ($p<0.001$) influence on the number of days it took for wrinkles to develop on tomato fruit. The longer it took for the fruits to wrinkle, the higher the basal chemical fertilizer application rate. The number of days to the appearance of wrinkles from the treatment application rate of the basal chemical fertilizer at 50 kg ha$^{-1}$, on the other hand, did not differ from the control treatment.

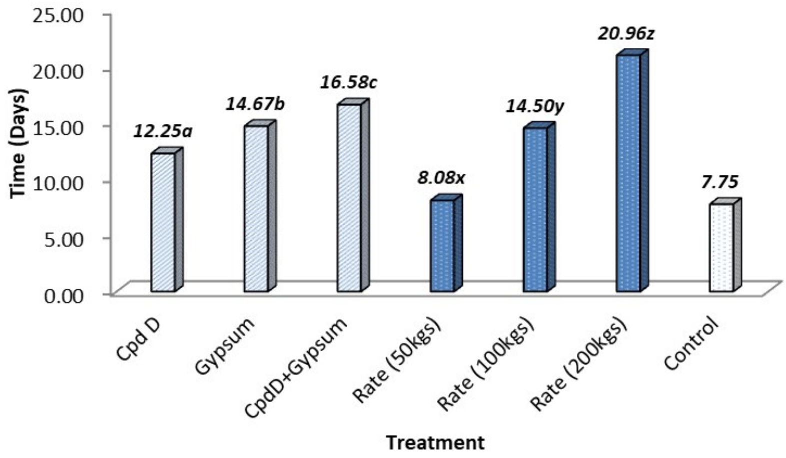


**Fig. 1.** Effect of type of chemical fertilizer and application rate on days to wrinkle appearance of fruit

### 3. 7. Days to watery

The effect of the type of basal chemical fertilizer used on fruit breakdown to a watery state varied statistically ($p<0.05$) (**Fig. 2**). The use of Compound D chemical fertilizer resulted in the shortest fruit shelf life. However, the effect of Compound D chemical fertilizer was enhanced when combined with Gypsum chemical fertilizer. Thus, increasing the levels of micronutrients, Ca and S, to the N-P-K in Compound D chemical fertilizer significantly improved tomato fruit shelf life. The application rate of the basal chemical fertilizers was increased from 50 kg ha$^{-1}$ to 200 kg ha$^{-1}$, which resulted in a significant ($p<0.001$) improvement in the shelf life of the tomato fruits. On the time taken for fruit to break down to a watery state, the lowest basal chemical fertilizer application rate of 50 kg ha$^{-1}$ did not differ from the control treatment.

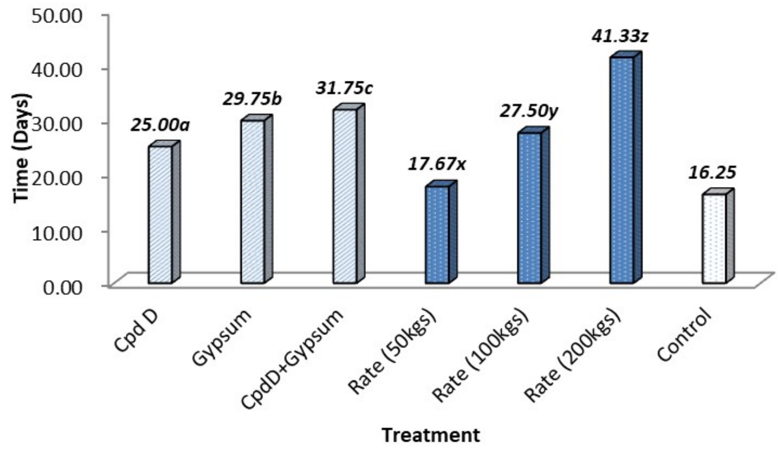


**Fig. 2.** Effect of type of chemical fertilizer and application rate on days to fruit break down to watery state

**3. 8. Weight loss**

**Fig. 3** depicts data on fruit weight loss as influenced by the type of basal chemical fertilizer and application rate. The effect of fertilizer type was significant ($p<0.001$), with plots treated with Compound D chemical fertilizer losing the most fruit weight. Tomatoes treated with a combination of Compound D+Gypsum basal chemical fertilizers had the lowest fruit weight loss. The effect of increasing the amount of basal chemical fertilizer had a positive effect on fruit percentage weight loss. At all levels, the control treatment lost significantly more fruit weight than the chemical fertilizer treatments.

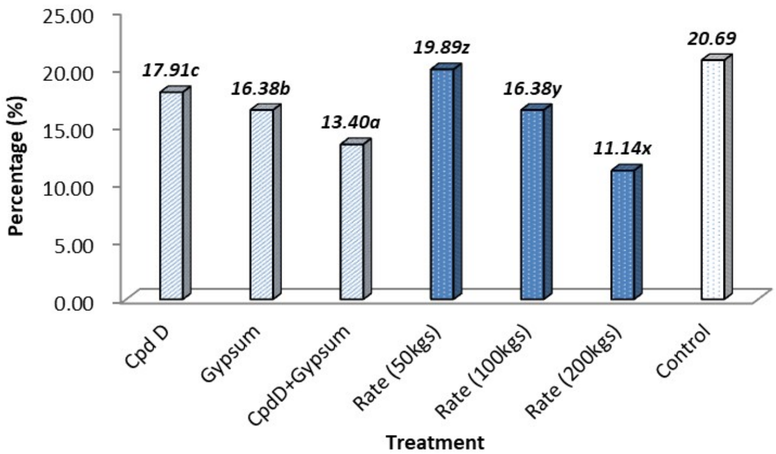


**Fig. 3.** Effect of type of chemical fertilizer and application rate on fruit weight loss

**4. Discussion**

The quality of tomato fruit changes continuously after harvesting. Most vegetables and fresh fruits have a high-water content (80–90 percent), which causes rapid water loss, which contributes to salable weight loss. Fruit weight loss, fruit breakdown, and the appearance of wrinkles are typically caused by tomato fruit desiccation and/or senescence. The addition of nitrogen, phosphorus, and potassium to chemical fertilizer extends the shelf life of tomato fruit [22]. The NPK is used to develop the cell structure, which increases the shelf life of the fruits. The influence of calcium in gypsum may have improved the shelf life of tomatoes treated with compound D and Gypsum. Calcium ions bind tightly to cell wall pectins, forming cationic bridges between pectic acids or between pectic acids and other acidic polysaccharides [23]. These bridges make the cell walls less accessible to the action of pectolytic enzymes and polyglacturonase, limiting moisture loss through the fruit cell wall [24, 25]. The calcium network formation with the pectin resulted in a lower weight in tomatoes that received calcium. Calcium accumulation in the cell walls may facilitate cross linking of the pectic polymers, increasing wall strength and cell cohesion in calcium-treated fruits [26, 27].

The calcium pectate formed is attributed to a reduction in cell wall degradation and, ultimately, a reduction in ethylene production, resulting in a low TSS by slowing metabolic activity and respiration, thereby retarding the ripening process [28, 29]. TSS values of tomato fruit treated with $CaCl_2$ were lower than those of control samples treated with water, yielding similar results [30]. The decrease in TSS of calcium-treated tomato fruit was most likely due to a slowing of respiration and metabolic activity, which slowed the ripening process [31]. Bustamante et al., [32] attributed low fruit TSS to the presence of better nutrients and phytohormones as a result of nutrient application.

Fruit treated with $CaCl_2$ retained firmness, according to Jain et al. [33]. Calcium ions may also influence tissue firmness by contributing to increased membrane integrity and, as a result, the maintenance or increase of cell turgor pressure [34], thereby delaying the time required for fruit tissue to degrade to a watery state. According to Ahmed et al. [35], an increase in potassium increases the firmness of the fruits. Javaria et al. [36] discovered that increasing the K dosage resulted in maximum firmness. Kanai et al. [37] attributed adequate K to increased shelf life in shipping quality of many horticultural crops. Cheour et al. [38] discovered that applying Ca to strawberries extended their shelf life as measured by a delay in sugar accumulation, a decrease in organic acids, an increase in color saturation index, and mold development. This explains why increasing the rate of chemical fertilizer application resulted in increased fruit shelf life.

The number of fruits with blossom end rot decreased as the application rate of basal chemical fertilizer increased. This is due to the Compound D in Gypsum containing NPK+S and Ca, which increases the essential mineral nutrients to the tomato crop. Calcium is known to have a significant impact on fruit ripening, and reducing ethylene production is one factor that can delay fruit senescence [39]. Tzoutzoukou and Bouranis [40] found that apricots treated with $CaCl_2$ produced significantly less ethylene. Calcium, according to Bhat et al. [41], has the ability to delay fruit ripening by inhibiting the biochemical patterns involved in these physiological processes. Contrary to these claims, the addition of Ca from Gypsum fertilizer increased fruit ripening in this study.

## 5. Conclusions

The study's findings show significant ($p<0.05$) differences due to the type of basal chemical fertilizer used and the rate of fertilizer application. The study concluded that applying Compound D+Gypsum at a rate of 200 kgs ha-1 produced significantly better results than other treatments. Simultaneously, increasing the rate of basal chemical fertilizer application was critical in improving postharvest parameters. Fruit firmness, TSS, weight loss, skin appearance, and fruit break down changes clearly indicate that fruit degradation begins after harvesting and that this negative effect can be slowed by determining the type of fertilizer and application rate.

## Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

## Financing

The study was performed without financial support.

## Data availability

Data will be made available on reasonable request.

## Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

## Acknowledgements

Gratitude is hereby expressed by the authors to the Engineering and Physics department for the utilization of resources and time in conducting this research and drafting the manuscript. A sincere appreciation also goes out to the technical team in the department for their valuable assistance in this study.

## References

[1] Masoso, F., Zingwari, O. A., Mutetwa, M., Zendera, W. (2020). Effect of different chemical fertilizers and application rate on tomato growth and yield. International Journal of Academic Research and Development, 5 (4), 119–124. Available at: https://www.academia.edu/44240395/Effect_of_different_chemical_fertilizers_and_application_rate_on_tomato_growth_and_yield

[2] Olaniyi, J., Akanbi, W., Adejumo, T. Ak, O. (2010). Growth, fruit yield and nutritional quality of tomato varieties. African Journal of Food Science, 4, 398–402. Available at: https://academicjournals.org/article/article1380726269_Olaniyi%20et%20al.pdf

[3] Dorais, M., Ehret, D. L., Papadopoulos, A. P. (2008). Tomato (Solanum lycopersicum) health components: from the seed to the consumer. Phytochemistry Reviews, 7 (2), 231–250. https://doi.org/10.1007/s11101-007-9085-x

[4] Preedy, V. R., Watson, R. R. (Eds.) (2008). Tomatoes and Tomato Products. CRC Press. https://doi.org/10.1201/9781439843390

[5] FAOSTAT. Food and Agriculture Organization of the United Nations Cropping Database. Available at: http://www.fao.org/faostat/en/#home

[6] Arah, L. K., Kumah, E. K., Anku, E. K., Amaglo, H. (2015). An overview of post-harvest losses in tomato production in Africa: causes and possible prevention strategies. Journal of Biology, Agriculture and Healthcare, 5 (16), 78–88. Available at: https://www.researchgate.net/publication/283507662_An_Overview_of_Post-Harvest_Losses_in_Tomato_Production_in_Africa_Causes_and_Possible_Prevention_Strategies

[7] Chapagain, B. P., Wiesman, Z. (2004). Effect of Nutri-Vant-PeaK foliar spray on plant development, yield, and fruit quality in greenhouse tomatoes. Scientia Horticulturae, 102 (2), 177–188. https://doi.org/10.1016/j.scienta.2003.12.010

[8] Beckles, D. M. (2012). Factors affecting the postharvest soluble solids and sugar content of tomato (Solanum lycopersicum L.) fruit. Postharvest Biology and Technology, 63 (1), 129–140. https://doi.org/10.1016/j.postharvbio.2011.05.016

[9] Tanweer, A., Goyal, G. K. (2007). Packaging and storage of tomato puree and paste. Stewart Postharvest Review, 3 (5), 1–8. https://doi.org/10.2212/spr.2007.5.1

[10] Zingwari, O. A., Zendera, W., Mtetwa, M. (2019). Effects of Biochar Produced at Different Pyrolysis Temperatures and Storage Environment on Ripening and Quality Characteristics of Tomatoes. Journal of Scientific and Engineering Research, 6 (9), 110–119. Available at: https://www.academia.edu/40498421/Effects_of_Biochar_Produced_at_Different_Pyrolysis_Temperatures_and_Storage_Environment_on_Ripening_and_Quality_Characteristics_of_Tomatoes

[11] Shimbo, S., Zhang, Z.-W., Watanabe, T., Nakatsuka, H., Matsuda-Inoguchi, N., Higashikawa, K., Ikeda, M. (2001). Cadmium and lead contents in rice and other cereal products in Japan in 1998–2000. Science of The Total Environment, 281 (1-3), 165–175. https://doi.org/10.1016/s0048-9697(01)00844-0

[12] Karungi, J., Ekbom, B., Kyamanywa, S. (2006). Effects of organic versus conventional fertilizers on insect pests, natural enemies and yield of Phaseolus vulgaris. Agriculture, Ecosystems & Environment, 115 (1-4), 51–55. https://doi.org/10.1016/j.agee.2005.12.008

[13] Armstrong, M. J., Kirkby, E. A. (1979). The influence of humidity on the mineral composition of tomato plants with special reference to calcium distribution. Plant and Soil, 52 (3), 427–435. https://doi.org/10.1007/bf02185585

[14] Faust, M., Klein, J. D. (1974). Levels and Sites of Metabolically Active Calcium in Apple Fruit. Journal of the American Society for Horticultural Science, 99 (1), 93–94. https://doi.org/10.21273/jashs.99.1.93

[15] Marschner, H. (1995). Functions of Mineral Nutrients. Mineral Nutrition of Higher Plants, 229–312. https://doi.org/10.1016/b978-012473542-2/50010-9

[16] Bangerth, F., Dilley, D. R., Dewey, D. H. (1972). Effect of Postharvest Calcium Treatments on Internal Breakdown and Respiration of Apple Fruits1. Journal of the American Society for Horticultural Science, 97 (5), 679–682. https://doi.org/10.21273/jashs.97.5.679

[17] Suzuki, K., Shono, M., Egawa, Y. (2003). Localization of calcium in the pericarp cells of tomato fruits during the development of blossom-end rot. Protoplasma, 222 (3-4), 149–156. https://doi.org/10.1007/s00709-003-0018-2

[18] Hecht-Buchholz, Ch. (1979). Calcium deficiency and plant ultrastructure. Communications in Soil Science and Plant Analysis, 10 (1-2), 67–81. https://doi.org/10.1080/00103627909366879

[19] Dodgson, J., Weston, A. K., Marks, D. J. (2023). Tomato Firmness and Shelf-Life Increased by Application of Stimulated Calcium. Crops, 3 (4), 251–265. https://doi.org/10.3390/crops3040023

[20] Ahmed, N., Zhang, B., Chachar, Z., Li, J., Xiao, G., Wang, Q. et al. (2024). Micronutrients and their effects on Horticultural crop quality, productivity and sustainability. Scientia Horticulturae, 323, 112512. https://doi.org/10.1016/j.scienta.2023.112512

[21] Nyamapfene, K. (1991). Soils of Zimbabwe. Harare, 179.

[22] Eboibi, O., Akpokodje, O. I., Nyorere, O., Oghenerukevwe, P., Uguru, H. (2021). Effect of pre-harvest applications of organic manure and calcium chloride on the storability of tomato fruits. Annals of Agricultural Sciences, 66 (2), 142–151. https://doi.org/10.1016/j.aoas.2021.10.001

[23] AOAC (2000). Official Methods of Analysis. The Association of Official Analytical Chemists, Gaithersburg, MD, USA.

[24] Ayour, J., Harrak, H., Benichou, M. (2024). Cell Wall Enzymatic Activity Control: A Reliable Technique in the Fruit Ripening Process. Food Science and Nutrition. https://doi.org/10.5772/intechopen.113752

[25] Wang, D., Yeats, T. H., Uluisik, S., Rose, J. K. C., Seymour, G. B. (2018). Fruit Softening: Revisiting the Role of Pectin. Trends in Plant Science, 23 (4), 302–310. https://doi.org/10.1016/j.tplants.2018.01.006

[26] Coulibaly, A. S., Kouakou, K. L., Dao, J. P., Kouakou, C., Dedi, J. K., Bi, I. A. Z. (2023). Enhancing Tomato (Solanum lycopersicum L.) Fruit Yield and Quality and Blossom End Rot Control Using Different Biological Calcium Sources. Journal of Agricultural Chemistry and Environment, 12(03), 263–274. https://doi.org/10.4236/jacen.2023.123020

[27] Atakhani, A., Bogdziewiez, L., Verger, S. (2022). Characterising the mechanics of cell–cell adhesion in plants. Quantitative Plant Biology, 3. https://doi.org/10.1017/qpb.2021.16

[28] Deaquiz, Y. A., Álvarez-Herrera, J., Fischer, G. (2014). Ethylene and 1-MCP affect the postharvest behavior of yellow pitahaya fruits (Selenicereus megalanthus Haw.). Agronomía Colombiana, 32 (1), 44–51. https://doi.org/10.15446/agron.colomb.v32n1.41950

[29] Sinha, A., Jawandha, S. K., Gill, P. P. S., Singh, H. (2019). Influence of pre-harvest sprays of calcium nitrate on storability and quality attributes of plum fruits. Journal of Food Science and Technology, 56 (3), 1427–1437. https://doi.org/10.1007/s13197-019-03621-z

[30] Pila, N., Neeta, B. G., Rao, T. V. R. (2010). Effect of Post harvest Treatments on Physicochemical Characteristics and Shelf Life of Tomato (Lycopersicon esculentum Mill.) Fruits during Storage. American-Eurasian Journal of Agricultural and Environmental Sciences, 9, 470–479. Available at: https://www.idosi.org/aejaes/jaes9(5)/3.pdf

[31] Zewdie, B., Shonte, T. T., Woldetsadik, K. (2022). Shelf life and quality of tomato ( Lycopersicon esculentum Mill.) fruits as affected by neem leaf extract dipping and beeswax coating. International Journal of Food Properties, 25 (1), 570–592. https://doi.org/10.1080/10942912.2022.2053709

[32] Bustamante, M., Muñoz, A., Romero, I., Osorio, P., Mánquez, S., Arriola, R. et al. (2021). Impact of Potassium Pre-Harvest Applications on Fruit Quality and Condition of Sweet Cherry (Prunus avium L.) Cultivated under Plastic Covers in Southern Chile Orchards. Plants, 10 (12), 2778. https://doi.org/10.3390/plants10122778

[33] Jain, V., Chawla, S., Choudhary, P., Jain, S. (2019). Post-harvest calcium chloride treatments influence fruit firmness, cell wall components and cell wall hydrolyzing enzymes of Ber (Ziziphus mauritiana Lamk.) fruits during storage. Journal of Food Science and Technology, 56 (10), 4535–4542. https://doi.org/10.1007/s13197-019-03934-z

[34] Wang, Y., Xie, X., Long, L. E. (2014). The effect of postharvest calcium application in hydro-cooling water on tissue calcium content, biochemical changes, and quality attributes of sweet cherry fruit. Food Chemistry, 160, 22–30. https://doi.org/10.1016/j.foodchem.2014.03.073

[35] Ahmad, N., Sarfraz, M., Farooq, U., Arfan-ul-Haq, M., Mushtaq, M. Z., Ali, M. A. (2015). Effect of potassium and its time of application on yield and quality of tomato. International Journal of Scientific and Research Publications, 5 (9), 1–4. Available at: https://www.ijsrp.org/research-paper-0915/ijsrp-p45120.pdf

[36] Javaria, S., Khan, M. Q., Bakhsh, I. (2012). Effect of potassium on chemical and sensory attributes of tomato fruit. The Journal of Animal & Plant Sciences, 22 (4), 1081–1085. Available at: https://www.researchgate.net/publication/288165478_Effect_of_potassium_on_chemical_and_sensory_attributes_of_tomato_fruit

[37] Kanai, S., Ohkura, K., Adu-Gyamfi, J. J., Mohapatra, P. K., Nguyen, N. T., Saneoka, H., Fujita, K. (2007). Depression of sink activity precedes the inhibition of biomass production in tomato plants subjected to potassium deficiency stress. Journal of Experimental Botany, 58 (11), 2917–2928. https://doi.org/10.1093/jxb/erm149

[38] Chéour, F., Willemot, C., Arul, J., Makhlouf, J., Desjardins, Y. (1991). Postharvest Response of Two Strawberry Cultivars to Foliar Application of CaCl2. HortScience, 26 (9), 1186–1188. https://doi.org/10.21273/hortsci.26.9.1186

[39] Tanaka, K., Yokota, M., Ishikawa-Takano, Y., Asakura, T., Miyairi, K., Okuno, T. (1998). Role of calcium in fruit involved in ethylene production. Acta Horticulturae, 464, 504–504. https://doi.org/10.17660/actahortic.1998.464.96

[40] Tzoutzoukou, C. G., Bouranis, D. L. (1997). Effect of preharvest application of calcium on the postharvest physiology of apricot fruit. Journal of Plant Nutrition, 20 (2-3), 295–309. https://doi.org/10.1080/01904169709365251

[41] Bhat, M. Y., Ahsan, H., Banday, F. A., Dar, M. A., Imtiyaz Wani, A., Hassan, G. I. (2012). Effect of harvest dates, pre harvest calcium sprays and storage period on physico-chemical characteristics of pear cv. Bartlett. E3 Journal of Agricultural Research and Development, 2 (4), 101–106. Available at: https://www.e3journals.org/cms/articles/1353252201_Bhat%20et%20al.pdf

*Received date 05.01.2024*
*Accepted date 14.03.2024*
*Published date 29.03.2024*



***How to cite:*** *Zingwari, O. A., Zendera, W., Masoso, F., Mtaita, T., Mutetwa, M. (2024). Evaluation of fertilizer type and rate of application on tomato fruit quality. EUREKA: Life Sciences, 1, 3–11. https://doi.org/10.21303/2504-5695.2024.003327*