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Effect of Foliar Application of nano Ca on qualitative Parameters of Tomato (*Solanum lycopersicum* L.)

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ABSTRACT: Indiscriminate application of these nutrients to the soil over years will lead to accumulation in soil, to the level toxic to plants. Therefore, an efficient mechanism is very essential to reduce the amount of nutrient (soil / foliar) application, without compromising the plant growth and yield is very essential. Hence, in recent years, the application of nanoscale particles is being preferred to enhance the agronomic effectiveness of nutrients in plants. In view of this, an experiment was conducted during *kharif*, 2020 to know the effect of foliar application of nano CaO on qualitative parameters of tomato. The experiment was laid out in a Completely Randomized Design (CRD) with thirteen treatments comprising different concentrations of nano CaO (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 and 1500 ppm), $CaNO_3$, and control. Each treatment was replicated thrice. The foliar application of nano CaO was done at 30 and 45 DAT. Nano CaO 600 ppm recorded minimum values for TSS (3.90 ^{0}Brix), pH (4.38), total sugars (2.40 %), reducing sugars (2.15 %), lycopene content (5.80 mg $100g^{-1}$) and maximum values for ascorbic acid (25.40 mg $100g^{-1}$) and titrable acidity (0.52%).

Keywords: Nano CaO, TSS, pH, total sugars, reducing sugars, lycopene content, ascorbic acid and titrable acidity

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the main vegetable crop extensively grown all over the globe. In India, tomato occupies an area of 0.56 million hectares with a production of 16.13 million tonnes (NHB Database, 2020-21). In Telangana, tomato is cultivated in an area of 0.025 million hectares with a production of 0.88 million tonnes (NHB Database, 2020-21).

Tomato requires both major and micronutrients for its proper plant growth (Sainju *et al.,* 2003). Calcium is an important secondary macronutrient, which may be deficient in plants either due to low calcium in the soil or low calcium availability due to high soil pH or low mobility in the plants (Kadir, 2004; Peter, 2005). Therefore, the endless offer of Ca is needed for leaf development, plant canopy, and vigorous root growth. Calcium plays a variety of structural roles in cells and also functions as a second messenger in plant growth, development and adoption to the environment (Del-Amor and Marcelis, 2006).

However, indiscriminate application of these nutrients to the soil over years will lead to accumulation in soil, to the level toxic to plants. Therefore, an efficient mechanism is very essential to reduce the amount of nutrient (soil / foliar) application, without compromising the plant growth and yield is very essential. Hence, in recent years, the application of nanoscale particles is being preferred to enhance the agronomic effectiveness of nutrients in plants. Nanotechnology is receiving attention from a diverse field of Science and Technology as it involves the synthesis and application of materials having size dimensions in the nanoscale (1-100 nm) (Khan *et al*., 2019). Nanoparticles are expected to exhibit higher reactivity because of their larger surface areas to volume ratio (Liu, 2006). The nano molecules applications in Agriculture are at their infancy. Nano fertilizers are a new generation of synthetic fertilizers that contain readily available nutrients on the nanoscale. Nano fertilizers are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. The use of nano fertilizers is expected to maintain better soil fertility and provide greater crop yields. Nano fertilizers can be easily absorbed by crops and may exhibit a prolonged effective duration of nutrient supply in soil/crop compared to conventional fertilizers. The actual movement of nanoparticles through the cuticle depends on the nutrient concentration. In view of the above, an attempt is being made to study the efficacy of foliar application of nano nutrients in tomato entitled "Effect of foliar application of nano CaO on qualitative parameters of tomato (*Solanum lycopersicum* L.)".

MATERIAL AND METHODS

The present investigation was carried out during *kharif*, 2020; at Agricultural College, Palem, Professor Jayashankar Telangana State Agricultural University. The nano particulates of Calcium were prepared in a nanotechnology laboratory at the Institute of Frontier Technology, Regional Agricultural Research Station, Tirupati. High-Resolution Transmission Electron Microscopy (HR-TEM) image analysis was carried out at the Indian Institute of Technology, Roorkee. The experiment was laid out in a Completely Randomized Design (CRD) with thirteen treatments comprising different concentrations of nano CaO, $CaNO_3$ and control and each treatment was replicated thrice. The foliar application of nano CaO was done at 30 and 45 DAT. The treatment details are as follows

T_1: Foliar spraying with $CaNO_3$ @ 2 g L^{-1} (2000 ppm)
T_2: Foliar spraying with nano CaO 100 ppm (0.1 g L^{-1})
T_3: Foliar spraying with nano CaO 200 ppm (0.2 g L^{-1})
T_4: Foliar spraying with nano CaO 300 ppm (0.3 g L^{-1})
T_5: Foliar spraying with nano CaO 400 ppm (0.4 g L^{-1})
T_6: Foliar spraying with nano CaO 500 ppm (0.5 g L^{-1})
T_7: Foliar spraying with nano CaO 600 ppm (0.6 g L^{-1})
T_8: Foliar spraying with nano CaO 700 ppm (0.7 g L^{-1})
T_9: Foliar spraying with nano CaO 800 ppm (0.8 g L^{-1})
T_{10}: Foliar spraying with nano CaO 900 ppm (0.9 g L^{-1})
T_{11}: Foliar spraying with nano CaO 1000 ppm (1.0 g L^{-1})
T_{12}: Foliar spraying with nano CaO 1500 ppm (1.5 g L^{-1})
T_{13}: Control (Without Calcium application)

Total Soluble Solids (^{o}Brix): The total soluble solids of the fruits were determined with the help of an Erma hand refractometer and expressed as ^{o}Brix (Ranganna, 1986).

pH : pH is the measurement of the logarithm of inverse ions in the solution.

$pH = -\log(H^+)$

Where, H^+= hydrogen ion concentration (g lit^{-1})

The pH values were determined with the help of an electronic pH meter. The electronic pH meter was calibrated using 4 pH, 7 pH and 9 pH standard buffer solutions.

Ascorbic acid content (mg 100g^{-1}): Ascorbic acid was estimated by the method outlined by Ranganna, (1986).

Ascorbic acid (mg 100g^{-1}) =

$$\frac{\text{Titre} \times \text{dye factor} \times \text{vol. made up} \times 100}{\begin{matrix}\text{Aliquot of extract} & \times \text{ weight of} \\ \text{Taken for estimation} & \text{sample taken}\end{matrix}}$$

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

Titrable acidity (%): Estimation of titratable acidity was carried out by using the method given by Ranganna (1986).

Titrable acidity (%) =

$$\frac{\begin{matrix}\text{Titre value} \times \text{normality of alkali} \times \\ \text{volume made} \times \text{ equivalent weight of acid} \\ \times 100\end{matrix}}{\text{Weight of sample} \times \text{Vol. of aliquot} \times 1000}$$

Total Sugars (%): Total sugars were estimated by the method outlined by Ranganna, (1986).

Total sugars (%) =

$$\frac{\text{Factor} \times \text{Volume made up} \times \text{Dilution} \times 1000}{\text{Titre value} \times \text{weight of sample}}$$

Reducing Sugars (%): The reducing sugars was determined by Lane and Eyon method described by Ranganna, 1986.

$$\text{Reducing sugars (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre} \times \text{weight of sample} \times 100}$$

Non-reducing sugars (%): The non-reducing sugar content in tomato was determined by subtracting the total sugars from the reducing sugars.

Non reducing sugars (%) = Total sugars (%) - Reducing sugars (%)

Lycopene content (mg 100g^{-1}): Milligrams of lycopene per 100gm sample, using the formula given by R.P. Srivastava and Kumar (2002)

O.D. of 1.0 = 3.1206 µg of lycopene / ml

Lycopene (mg 100g^{-1}) =

$$\frac{3.1206 \times \text{OD of sample} \times \text{Vol. of made - up} \times \text{Dilution} \times 100}{\text{Weight of sample} \times 1000}$$

RESULTS AND DISCUSSION

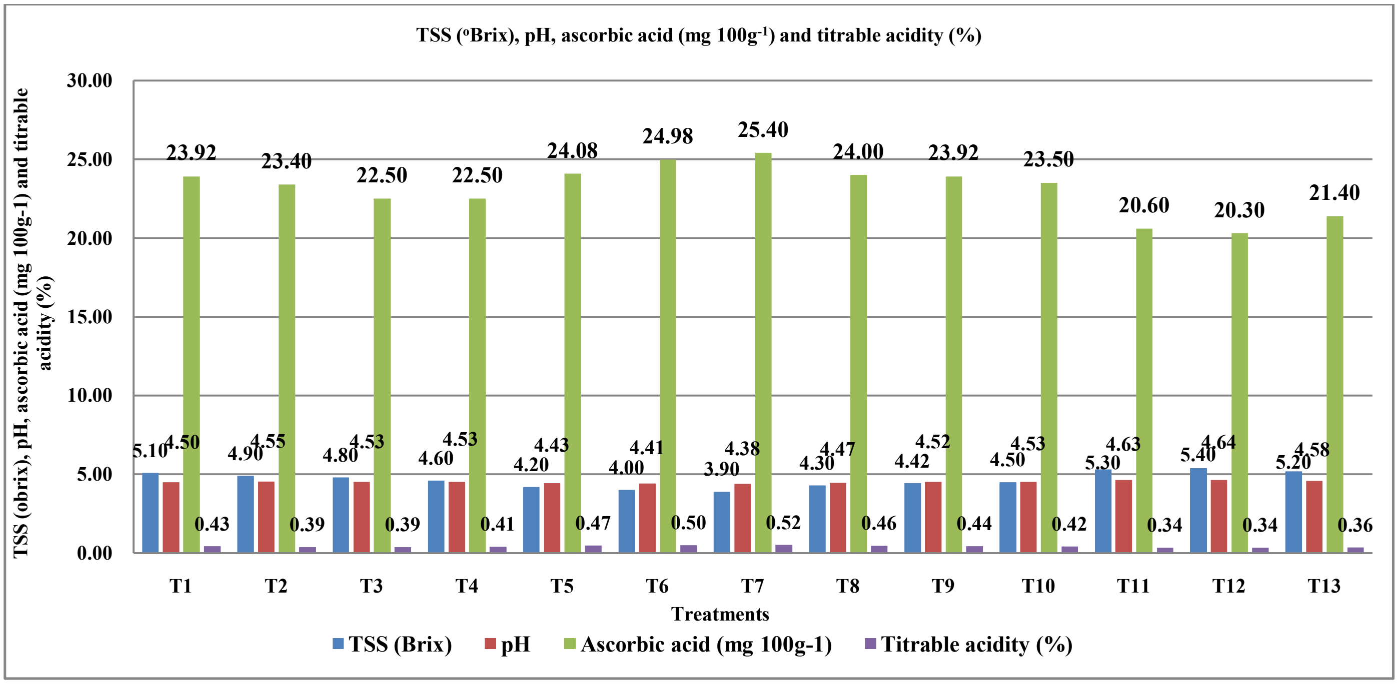
Total soluble solids (^{o}Brix): It is evident from the data that (Table 1 and Fig. 1), among the treatments, nano CaO 600 ppm was recorded lowest TSS (3.90 ^{o}Brix), which was statistically on par with nano CaO 500 ppm (4.00 ^{o}Brix), while significantly highest TSS has recorded in nano CaO 1500 ppm (5.40 ^{o}Brix). The significant effect of nano CaO in maintaining low TSS might be due to the binding of calcium with pectin contents in the cell wall by forming the salt bridge between Ca^{+2} and COO group (Stanly *et al.,* 1995). Due to this, calcium pectate is formed which helps in reducing the degradation of the cell wall and ultimately reduces the ethylene production resulting in maintaining low TSS by slowing down the ripening process. The present investigation confirmed with reports of Rab and Haq (2012) in tomato, Amini *et al.* (2016) in sweet pepper and Haleema *et al.* (2020) in tomato.

pH: All treatments had a significant influence on pH (Table 1 and Fig. 1). Among all the treatments, nano

CaO 600 ppm recorded the lowest pH (4.38) and it was on par with nano CaO 500 ppm (4.41) and nano CaO 400 ppm (4.43), while it was significantly highest in nano CaO 1500 ppm (4.64). The lowest pH was reported in nano CaO treated plants at optimum concentrations. Fruits containing less pH indicate the presence of more citric acid, which is more suitable for processing and improves shelf life (Hernandez-Perez *et al.,* 2005). Similar results were also reported by Amini *et al.* (2016) in sweet pepper.

Table 1: Effect of foliar spraying of nano CaO on TSS (°Brix), pH, ascorbic acid (mg $100g^{-1}$) and titrable acidity (%) of tomato grown in polybags.

Treatments	TSS (°Brix)	pH	Ascorbic acid (mg $100g^{-1}$)	Titrable acidity (%)
T_1: Foliar spraying with $CaNO_3$ @ 2 g L^{-1}	5.10	4.50	23.92	0.43
T_2: Foliar spraying with nano CaO 100 ppm	4.90	4.55	23.40	0.39
T_3: Foliar spraying with nano CaO 200 ppm	4.80	4.53	22.50	0.39
T_4: Foliar spraying with nano CaO 300 ppm	4.60	4.53	22.50	0.41
T_5: Foliar spraying with nano CaO 400 ppm	4.20	4.43	24.08	0.47
T_6: Foliar spraying with nano CaO 500 ppm	4.00	4.41	24.98	0.50
T_7: Foliar spraying with nano CaO 600 ppm	3.90	4.38	25.40	0.52
T_8: Foliar spraying with nano CaO 700 ppm	4.30	4.47	24.00	0.46
T_9: Foliar spraying with nano CaO 800 ppm	4.42	4.52	23.92	0.44
T_{10}: Foliar spraying with nano CaO 900 ppm	4.50	4.53	23.50	0.42
T_{11}: Foliar spraying with nano CaO 1000 ppm	5.30	4.63	20.60	0.34
T_{12}: Foliar spraying with nano CaO 1500 ppm	5.40	4.64	20.30	0.34
T_{13}: Control (Without calcium application)	5.20	4.58	21.40	0.36
SEm±	**0.06**	**0.03**	**0.45**	**0.01**
CD (P=0.05)	**0.18**	**0.09**	**1.32**	**0.03**



T_1 : Foliar spraying with $CaNO_3$ @ 2 g L^{-1}
T_2 : Foliar spraying with nano CaO 100 ppm
T_3 : Foliar spraying with nano CaO 200 ppm
T_4 : Foliar spraying with nano CaO 300 ppm
T_5 : Foliar spraying with nano CaO 400 ppm
T_6 : Foliar spraying with nano CaO 500 ppm
T_7 : Foliar spraying with nano CaO 600 ppm
T_8 : Foliar spraying with nano CaO 700 ppm
T_9 : Foliar spraying with nano CaO 800 ppm
T_{10} : Foliar spraying with nano CaO 900 ppm
T_{11} : Foliar spraying with nano CaO 1000 ppm
T_{12}: Foliar spraying with nano CaO 1500 ppm
T_{13} : Control (Without calcium application)

Fig. 1. Effect of foliar spraying of nano CaO on TSS (°Brix), pH, ascorbic acid (mg $100g^{-1}$) and titrable acidity (%) of tomato grown in polybags.

Ascorbic acid (mg $100g^{-1}$): Maximum ascorbic acid was registered in nano CaO 600 ppm (25.40 mg 100 g^{-1}) which was on par with nano CaO 500 ppm (24.98 mg $100g^{-1}$) and T_5 (nano CaO 400 ppm) (24.08 mg $100g^{-1}$), while significantly minimum ascorbic acid was recorded with nano CaO 1500 ppm (20.30 mg $100g^{-1}$). Ascorbic acid was recorded with a lower concentration of nano CaO such as, nano CaO 100 ppm (23.40 mg $100g^{-1}$), nano CaO 200 ppm (22.50 mg $100g^{-1}$) and nano CaO 300 ppm (22.50 mg $100g^{-1}$) were on par with each other. When nano CaO concentrations exceeded 600 ppm, the ascorbic acid content decreased. It was also noted that nano CaO 1000 ppm and nano CaO 1500 ppm had lesser ascorbic acid than $CaNO_3$ @ 2 g L^{-1} (23.92 mg $100g^{-1}$) and control (21.40 mg $100g^{-1}$). This could be linked to the phytotoxicity effect of elements at higher concentrations (Table 1 and Fig. 1). Nano CaO delayed metabolic activities like respiration rate and ethylene production due to which higher ascorbic acid was noticed in nano CaO treated plants compared to control. These results were in accordance with the findings of Zakaria *et al.* (2018) in strawberries and Haleema *et al.* (2020) in tomato.

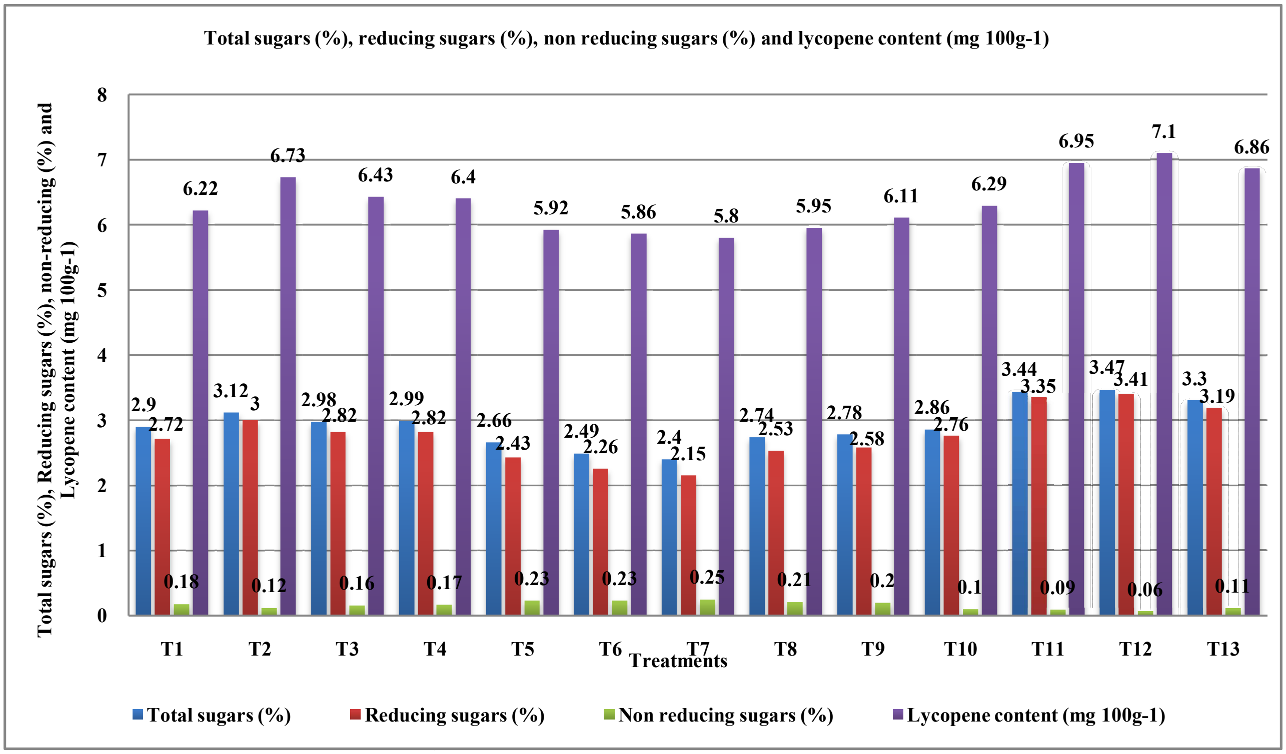
Titrable acidity (%): The results indicated that foliar spraying of nano CaO and $CaNO_3$ with varied doses recorded a significant influence on the percentage of titrable acidity (Table 1 and Fig. 1). Among the treatments, nano CaO 600 ppm recorded the highest percentage of titrable acidity (0.52 %), which was on par with nano CaO 500 ppm (0.50 %), while it was significantly lowest in nano CaO 1000 ppm and nano CaO 1500 ppm (0.34 %). A higher percentage of titrable acidity was reported in nano CaO treated plants as it delayed fruit ripening and reduced respiration rate, which ultimately reduce organic acid hydrolysis, *i.e.* metabolic conversion of organic acid into carbon dioxide and water (Mosa *et al.* 2015). Similar results were in accordance with the finding of Ibrahim (2005) in apricot, Ramana-Rao *et al.* (2011) in sweet pepper, Ranjbar *et al.* (2019) in apple, and Haleema *et al.* (2020) in tomato.

Total sugars (%): The data (Table 2 and Fig. 2) enunciated on total sugars as influenced by the foliar spraying of nano CaO and $CaNO_3$ revealed that, nano CaO 600 ppm recorded minimum total sugars (2.40 %), which was on par with nano CaO 500 ppm (2.49 %), while it was significantly maximum in nano CaO 1500 ppm (3.47 %). The lower concentration of nano CaO, such as nano CaO 100 ppm, nano CaO 300 ppm and nano CaO 200 ppm recorded total sugars @ 3.12 %, 2.99 % and 2.98 % respectively. These are on par with each other. Total sugars increased when the concentration of nano CaO increased beyond 600 ppm. It was also noted that nano CaO 1000 ppm and nano CaO 1500 ppm recorded more total sugars compared to $CaNO_3$ @ 2 g L^{-1} (2.90 %) and control (3.30 %). This could be associated with the phytotoxicity effect of this element observed at higher concentrations.

Reducing sugars (%): Foliar application of CaO and $CaNO_3$ recorded a significant influence on reducing sugars (Table 2 and Fig. 2). Among all the treatments, nano CaO 600 ppm recorded the lowest reducing sugars (2.15 %) and it was on par with nano CaO 500 ppm (2.29 %), while it was significantly highest (3.41 %) in nano CaO 1500 ppm. The lower total sugars and reducing sugars were reported in nano CaO treatments where calcium reduces the activity of enzymes responsible for the hydrolysis of polysaccharides to monosaccharides (Agar *et al.* 1999), delaying ripening, decreasing respiration and metabolic activities (Rohani *et al.* 1997). Generally, sugars increase with ripening might be due to the metabolic breakdown of polysaccharides into water-soluble sugars and organic acids into carbon dioxide. These results were in accordance with the finding of Rajkumar and Mitali (2009) in water apple fruits, Sood *et al.* (2014) in tomato, Zakaria *et al.* (2018) in strawberries, Haleema *et al.* (2020) in tomato.

Table 2: Effect of foliar spraying of nano CaO on total sugars (%), reducing sugars (%), non-reducing sugars (%) and lycopene content (mg $100g^{-1}$) of tomato grown in polybags.

Treatments	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Lycopene content (mg $100g^{-1}$)
T_1: Foliar spraying with $CaNO_3$ @ 2 g L^{-1}	2.90	2.72	0.18	6.22
T_2: Foliar spraying with nano CaO 100 ppm	3.12	3.00	0.12	6.73
T_3: Foliar spraying with nano CaO 200 ppm	2.98	2.82	016	6.43
T_4 : Foliar spraying with nano CaO 300 ppm	2.99	2.82	0.17	6.40
T_5 : Foliar spraying with nano CaO 400 ppm	2.66	2.43	0.23	5.92
T_6 : Foliar spraying with nano CaO 500 ppm	2.49	2.26	0.23	5.86
T_7 : Foliar spraying with nano CaO 600 ppm	2.40	2.15	0.25	5.80
T_8 : Foliar spraying with nano CaO 700 ppm	2.74	2.53	0.21	5.95
T_9 : Foliar spraying with nano CaO 800 ppm	2.78	2.58	0.20	6.11
T_{10} : Foliar spraying with nano CaO 900 ppm	2.86	2.76	0.10	6.29
T_{11} : Foliar spraying with nano CaO 1000 ppm	3.44	3.35	0.09	6.95
T_{12}: Foliar spraying with nano CaO 1500 ppm	3.47	3.41	0.06	7.10
T_{13} : Control (Without calcium application)	3.30	3.19	0.11	6.86
SEm±	**0.06**	**0.04**	**0.003**	**0.09**
CD (P=0.05)	**0.17**	**0.12**	**0.01**	**0.25**



T_1 : Foliar spraying with $CaNO_3$ @ 2 g L^{-1}
T_2 : Foliar spraying with nano CaO 100 ppm
T_3 : Foliar spraying with nano CaO 200 ppm
T_4 : Foliar spraying with nano CaO 300 ppm
T_5 : Foliar spraying with nano CaO 400 ppm
T_6 : Foliar spraying with nano CaO 500 ppm
T_7 : Foliar spraying with nano CaO 600 ppm
T_8 : Foliar spraying with nano CaO 700 ppm
T_9 : Foliar spraying with nano CaO 800 ppm
T_{10} : Foliar spraying with nano CaO 900 ppm
T_{11} : Foliar spraying with nano CaO 1000 ppm
T_{12}: Foliar spraying with nano CaO 1500 ppm
T_{13} : Control (Without calcium application)

Fig. 2. Effect of foliar spraying of nano CaO on total sugars (%), reducing sugars (%), non-reducing sugars (%) and lycopene content (mg $100g^{-1}$) of tomato grown in polybags.

Non-reducing sugars (%): nano CaO 600 ppm significantly recorded the highest non-reducing sugars (0.25 %) followed by nano CaO 500 ppm (0.23 %) and nano CaO 400 ppm (0.23 %), while it was significantly lowest (0.06 %) in nano CaO 1000 ppm (Table 2 and Fig. 2).

Lycopene content (mg $100g^{-1}$): The observations from Table 2 confirm that, nano CaO 600 ppm recorded the lowest value of lycopene content (5.80 mg $100g^{-1}$), which was on par with nano CaO 500 ppm (5.86 mg $100g^{-1}$), nano CaO 400 ppm (5.92 mg $100g^{-1}$) and nano CaO 700 ppm (5.95 mg $100g^{-1}$), while it was significantly highest in nano CaO 1000 ppm (7.10 mg $100g^{-1}$) which was on par with nano CaO 1000 ppm (6.95 mg $100g^{-1}$), and control (6.86 mg $100g^{-1}$). An increasing trend in lycopene content was observed when the concentration of nano CaO increased beyond 600 ppm. It was also noted that nano CaO 1000 ppm and nano CaO 1500 ppm recorded more lycopene content compared to $CaNO_3$ @ 2 g L^{-1} (6.22 mg $100g^{-1}$). This could be associated with the phytotoxicity effect of this element observed at higher concentrations. The lowest lycopene content was reported in nano CaO 600 ppm. The reason for failure in skin colour development is the effect of nano CaO on the ethylene generating cycle, which affected lycopene pigment synthesis during the ripening process (Njoroge *et al.*, 1998). These results were in accordance with the finding of Sood *et al.* (2014) on tomato.

CONCLUSION

Foliar spraying of nano CaO significantly influenced the TSS, pH, total sugars, reducing sugars, lycopene content ascorbic acid and titrable acidity of tomato. Nano CaO 600 ppm recorded minimum values for TSS, pH, total sugars, reducing sugars, lycopene content and maximum values for ascorbic acid and titrable acidity.

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