# EFFECT OF FOLIAR SPRAYING OF NANO ZnO ON QUALITATIVE AND PHYSICAL PARAMETERS OF TOMATO GROWN IN POLYBAGS


## ABSTRACT:

**Background:** Tomato (*Solanum lycopersicum*L.) is the main vegetable crop extensively grown all over the globe. Tomato requires both major and micronutrients for its proper plant growth (Sainju*et al*., 2003). Nano fertilizers are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. 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.

**Methods:** A polybag experiment was conducted during Kharif, 2020-21 at Agricultural College, Palem, PJTSAU, in a completely randomized design (CRD) with fourteen treatments comprising different concentrations of nano ZnO (50, 100, 250, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250 and 2500 ppm), $ZnSO_4$ and control.

**Result:** Foliar spraying of nano ZnO 1000 ppm recorded the lowest total soluble solids (4.00 $^0$brix), highest ascorbic acid (23.71 mg $100g^{-1}$), highest titrable acidity (0.48 %), lowest percentage of total sugars (2.80 %), lowest percentage of reducing sugars (2.48 %), highest percentage (0.32 %) of non-reducing sugars and highest value of lycopene content (6.64 mg $100g^{-1}$), maximum shelf life (11.67 days) and firmness (3.05 kg $cm^{-2}$). On 3$^{rd}$, 6$^{th}$ and 9$^{th}$ day after harvest, same treatmentrecorded minimum physiological loss in weight(3.64 %, 6.36 % and 8.51 %).



**Key words:** Tomato, nano ZnO, TSS, ascorbic acid, titrable acidity, total sugars, physiological loss in weight


## INTRODUCTION:

Tomato (*Solanum lycopersicum*L.) is the main vegetable crop extensively grown all over the globe.

Tomato requires both major and micronutrients for its proper plant growth (Sainju*et al*., 2003). Among micronutrients, Zn and B are important for plant nutrition. In India among all themicronutrients, zinc is considered as the fourth most important yield-limiting nutrient in crops. Ithas been postulated that zinc deficiency is likely to increase from 49- 63 percent by the year 2025 as most of the marginal soils brought under cultivation are showing the symptoms of zinc deficiency (Arunachalam *et al*., 2013). Zn plays an

UNDER PEER REVIEW

important role in growth and development as well as carbohydrates, protein metabolism and sexual fertilization of plants (Imtiaz *et al*., 2003).

Nano fertilizers are a new generation of synthetic fertilizers which contain readily available nutrients onthe nanoscale. These are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. 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.Due to the above reasons, an attempt was made to study the efficacy of foliar application of nano Zn in tomato.

## MATERIAL AND METHODS

The present investigation was carried out in Kharif, 2020; at Agricultural College, Palem, Professor Jayashankar Telangana State Agricultural University. The nano particulates of zinc 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 fourteen treatments comprising different concentrations of nano Zn, $ZnSO_4$and control. Each treatment was replicated thrice. The foliar application of nano boron was done at 30 and 45 DAT. The treatments details are as follows:

**Treatmentsdetails:**

$T_1$: FoliarsprayingwithZnSO$_4$@5gL$^{-1}$(5000ppm)

$T_2$: Foliar spraying with nano ZnO 50 ppm (0.05 g L$^{-1}$)

$T_3$: Foliar spraying with nano ZnO 50 ppm (0.05 g L$^{-1}$)

$T_4$: Foliar spraying with nano ZnO 250 ppm (0.25 g L$^{-1}$)

$T_5$: Foliar spraying with nano ZnO 250 ppm (0.25 g L$^{-1}$)

$T_6$: Foliar spraying with nano ZnO 750 ppm (0.75 g L$^{-1}$)

$T_7$: Foliar spraying with nano ZnO 1000 ppm (1.0 g L$^{-1}$)

$T_8$: Foliar spraying with nano ZnO 1250 ppm (1.25 g L$^{-1}$)

$T_9$: FoliarsprayingwithnanoZnO1500ppm(1.5 gL$^{-1}$)

$T_{10}$: FoliarsprayingwithnanoZnO1500ppm(1.5 gL$^{-1}$)

$T_{11}$: Foliar spraying with nano ZnO 2000 ppm (2.0 g L$^{-1}$)

$T_{12}$: Foliar spraying with nano ZnO 2250 ppm (2.25 g L$^{-1}$)

UNDER PEER REVIEW

$T_{13}$: Foliar spraying with nano ZnO 2250 ppm (2.25 g $L^{-1}$)

$T_{14}$: Control(WithoutZincapplication)

**Total Soluble Solids ($^0$brix):** The total soluble solids of the fruits were determined with the help of an Erma hand refractometer and expressed as $^0$brix.

**pH:** The pH values were determined with the help of an electronic pH meter.

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

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

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

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

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

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

**Physiologicallossinweight(%):** Physiological loss in weight (PLW) was determined by recording the initialweightofthefruitsonthedayofinitiatingexperimentandsubsequentlyatthree days intervals. Thelossofweightingramsandinrelationtoinitialweightwascalculatedand expressed in percentage.

$$\textbf{PLW(\%)} = \frac{\text{(Initialweight–Final weight)}}{\text{Initialweight}} \times 100$$

**ShelfLife(Days):** Shelf life of the fruits was determined by recording the number of days thefruits remained in good condition in storage. The stage where in more than 50percent of the stored fruits became unfit for consumption was considered as end ofshelflifeinthatparticulartreatmentandexpressedasmeannumberofdays(PadmajaandBosco, 2014).

**Firmness(kg cm$^{-2}$):** Penetrometer was used to record the firmness of fruits and direct readingswere obtained in terms of kg cm$^{-2}$. The sample fruits were subjected to penetrometerbypressingnearthecenterofthefruitanddirectreadingonthescalewasrecorded

## RESULTS AND DISCUSSIONS

UNDER PEER REVIEW

**Total soluble solids ($^0$brix):**Data present in table 1 indicates that, a decreasing trend of total soluble solids was found with the increased level of nano ZnO up to 1000 ppm. Among the treatments, $T_7$ (nano ZnO 1000 ppm) recorded the lowest total soluble solids (4.00 $^0$brix), which was on par with $T_6$ (nano ZnO 750 ppm) (4.10 $^0$brix), while it was significantly high (5.40 $^0$brix)in $T_{13}$ (nano ZnO 2500 ppm). It might be due to its involvement in synthesis of tryptophan that is a precursor of auxin, auxins help in mobilization of carbohydrate from source to sink which intern increases TSS.

**Ascorbic acid (mg 100g$^{-1}$):**It is evident from the data that, highest ascorbic acid (23.71 mg 100g$^{-1}$) was registered with foliar spraying of nano ZnO 1000 ppm, which was on par with $T_6$, $T_{5,}$ and $T_8$(Table 1). Increased ascorbic acid with the application of zinc might be due to its role as a component of many proteins, particularly carbonic anhydrase and carboxylase that led to enhanced vitamin C content of the fruit.

The minimum ascorbic acid content was recorded in $T_{13}$which was on par with $T_{12}$ and $T_{11}$. This could be linked to phytotoxicity effect of elements at higher concentrations.

These results are in conformity with Quincy*et al.* (2020) in tomato and Prasad *et al*. (2021) in tomato.

**Titrable acidity (%):**The data (Table 1) enunciated on titrable acidity as influenced by the foliar spraying of nano zinc and $ZnSO_4$ revealed that, among the treatments, $T_7$ (nano ZnO 1000 ppm) recorded the highest titrable acidity (0.48 %), which was on par with $T_6$. The increased titrable acidity content in tomato fruits with the application of zinc might be due to its role in carbohydrate metabolism and synthesis of related enzymes. While it was significantly low in both $T_{12}$ (nano ZnO 2250 ppm) (0.33 %) and $T_{13}$ (nano ZnO 2500 ppm) (0.33 %) which was on par with $T_{11}$ (nano ZnO 2000 ppm) (0.34 %).

**Total sugars (%), Reducing sugars (%):**Lowest percentage of total sugars (2.80 %), reducing sugars (2.48 %) was registered in $T_7$ (nano ZnO 1000 ppm) which was on par with $T_6$, $T_{5,}$ $T_8$ and $T_1$. The highest percentage of total sugars (3.33 %), reducing sugars (3.22 %) was recorded with $T_{13}$ (nano ZnO 2500 ppm) (Table 1).

Reason for decreasing the total sugars and reducing sugars is, it is a component of molecular structure of enzymes carbonic anhydrase which is involved in photosynthesis and causes an increase in the level of soluble sugars (Marschner, 1995). Application of micronutrients may increase the mobilization of carbohydrates from source to sink. An association of zinc with synthesis of auxins in plants played a vital role in increasing enzymatic activities. This leads the bio bio-chemical reactions involving the conversion of

UNDER PEER REVIEW

complex food i.e. starch into simple sugars (Henare *et al.*, 2010, Mishra *et al.*, 2012 and Ramiar and Karami, 2016).

The increasing trend of total sugars was found in the present study with the increased level of nano ZnO from nano ZnO 1250 ppm ($T_8$) to nano ZnO 2500 ppm ($T_{13}$).

**Non - reducing sugars (%):**The results present in (Table 1) indicates that, foliar spraying of nano ZnO and $ZnSO_4$ with varied doses recorded significant influence on non-reducing sugars (%)**.** Among the treatments, $T_7$ (nano ZnO 1000 ppm) recorded the highest percentage (0.32 %) of non-reducing sugars, while it was significantly low in $T_{13}$ (nano ZnO 2500 ppm) (0.11 %).

**Lycopene content (mg 100g$^{-1}$):**The observations from table 1 confirm that $T_7$ (nano ZnO 1000 ppm) recorded the highest value of lycopene content (6.64 mg 100g$^{-1}$) which was on par with $T_6$, $T_8$ and $T_9$. The minimum lycopene content (5.83 mg 100g$^{-}$1) was recorded in $T_{13}$.These results are in accordance with the findings of Salam*et al.*, (2010) in tomatoesand Mishra *et al.*, (2012) in tomatoes.

High concentrations of nano ZnO ($T_{11,}$ $T_{12}$ and $T_{13}$) recorded lessascorbic acid, titrable acidity, Non – reducing sugars, lycopene content and high total soluble solids, total sugars, reducing sugars than $ZnSO_4$and control. This could be associated with the phytotoxicity effect of this element at higher concentrations.

**Physiological loss in weight (%):**From the data (table 2) pertaining to percentage of physiological loss in weight at 3$^{rd}$, 6$^{th}$, 9$^{th}$ and 12$^{th}$ day after harvest, as influenced by the foliar application of nano ZnO and $ZnSO_4$ it is observed that the percent of physiological loss in weight values showed an increasing trend from 3$^{rd}$ to 12$^{th}$ day after harvest during storage.

On 3$^{rd}$, 6$^{th}$ and 9$^{th}$ day after harvest, $T_7$ (nano ZnO 1000 ppm) recorded minimum physiological loss in weight (3.64 %, 6.36 % and 8.51 %) which was on par with $T_6$, while it was significantly maximum(4.24 %) in $T_{13}$ (nano ZnO 2500 ppm).On 9$^{th}$ day after harvest $T_{11}$, $T_{12}$ and $T_{13}$ treatments showed the end of shelf life.

On 12$^{th}$ day after harvest all treatments showed the end of shelf life. The results are supported by Saba and Amini (2017) in pomegranate.

**Shelf life (days):**It is evident from the data (table 2) that, among the treatments, $T_7$ (nano ZnO 1000 ppm) recorded highest shelf life (11.67 days) which was on par with $T_6$ (nano ZnO 750 ppm) (11.50 days), $T_5$ (nano ZnO 500 ppm) (11.33 days) and $T_8$ (nano ZnO 1250 ppm) (11.03 days). The minimum shelf life was recorded with $T_{13}$ (nano ZnO 2500 ppm) (9.00 days).

UNDER PEER REVIEW

**Firmness (kg cm$^{-2}$):**Firmness is important tomato character needed for long distance transport. The higher the firmness is, the less is the ratio of water to the flesh. As a result, the fruit will be more tolerant to transportation damages.The observations from table 2 confirm that $T_7$ (nano ZnO 1000 ppm) recorded the highest value of fruit firmness (3.05 kg cm$^{-2}$) which was on par with $T_6$ (nano ZnO 750 ppm) (3.00 kg cm$^{-2}$). The minimum firmness (1.90 kg cm$^{-2}$)was recorded in $T_{13}$ (nano ZnO 2500 ppm). The reason for increasing the firmness with the application of Zn might be due to it stimulates carbohydrates, proteins, DNA and RNA formation. Zinc plays an important role in synthesis of cell walls which helps to withstand prolonged periods without desiccation of middle lamella, as a result,improves resistance power against microbial activities, thereby decreasing the physiological loss in weight,increasing the shelf life and firmness (Mishra *et al.*, 2012, Ullah *et al.*, 2015). Zinc also helps to overcome heat stress as a result the surface skin of fruit will not be distorted easily as a result improves the post-harvest storage quality (Prasad *et al*., 2021).These results were found to be in line with those reported by Li *et al*. (2011) in apple, Xu *et al*. (2017) in carrot and Prasad *et al*. (2021) in tomato.

## CONCLUSION

Foliar spraying of nano ZnOexhibited a significant effect on quality and physical parameters of tomato. Among the different concentrations, nano ZnO 1000 ppm recorded the lowest total soluble solids (4.00 $^0$brix), highest ascorbic acid (23.71 mg 100g$^{-1}$), highest titrable acidity (0.48 %), lowest percentage of total sugars (2.80 %), lowest percentage of reducing sugars (2.48 %), highest percentage (0.32 %) of non-reducing sugars and highest value of lycopene content (6.64 mg 100g$^{-1}$), maximum shelf life (11.67 days) and firmness (3.05 kg cm$^{-2}$). On 3$^{rd}$, 6$^{th}$ and 9$^{th}$ day after harvest, same treatmentrecorded minimum physiological loss in weight(3.64 %, 6.36 % and 8.51 %). On 12$^{th}$ day after harvest, all treatments showed the end of shelf life.

## REFERENCES


Mishra BK, Saho CR, RajkumaryBhol. 2012. Effect of foliar application of micronutrients on growth, yield and quality of tomato cv. Utkalurbasi. *Environment and Ecology*.30(3):856-859.

Li, X., W. Li, Y. Jiang, Y. Ding, J. Yun, Y. Tang, and P. Zhang. 2011. Effect of nano-ZnO-coated active packaging on quality of fresh-cut ‘fuji’ apple. *International Journal of Food Science & Technology*. 46(9):1947-1955.


UNDER PEER REVIEW

Prasad, P. N. S., Subbarayappa, C. T., Sathish, A. and Ramamurthy, V. (2021). Impact of Zinc Fertilization on Tomato (*Solanum lycopersicum* L.) Yield, Zinc use Efficiency, Growth and Quality Parameters in Eastern Dry Zone (EDZ) Soils of Karnataka, India. *International Journal of Plant and Soil Science*, 20-38.

Ullah, R., Ayub, G., Ilyas, M., Ahmad, M., Umar, M., Mukhtar, S and Farooq, S. 2015. Growth and Yield of Tomato (*Lycopersiconesculentum* L.) as influenced by different Levels of Zinc and Boron as Foliar application. *American-Eurasian Journal of Agriculture and Environmental Science.* 15(12): 2495-2498.

Xu, J., M. Zhang, B. Bhandari, and R. Kachele. 2017. ZnO nanoparticles combined radio frequency heating: A novel method to control microorganism and improve product quality of prepared carrots. *Innovative Food Science and Emerging Technologies*. 44:46–53.

Salam, M. A., Siddique, M. A., Rahim, M. A., Rahman, M. A., & Saha, M. G. (2010). Quality of tomato (*Lycopersicon esculentum* Mill.) as influenced by boron and zinc under different levels of NPK fertilizers. *Bangladesh Journal of Agricultural Research*. 35(3): 475-488.

Henare M, Rezai HJ, Doulati H, Motalebi AR. 2010. Effects of calcium chloride spraying and cultivar on the shelf life of tomato. *AppliedFood Research.*1(20):47-72.

Ramiar A, Karami E. 2016. Effect of macro and microelements foliar spray on the quality and quantity of tomato. *International Journal of Agricultural Policy* and *Research*. 4(2):22-28.

Quincy, E. Ybanez., Pearl, B.S., Rodrigo, B.B. and Josephine, U.A. 2020. Synthesis and characterization of nano zinc oxide foliar fertilizer and its influence on yield and postharvest quality of tomato.*Philippine Agricultural Scientist*. 103(1): 55-65.

Saba, M. K., and R. Amini. 2017. Nano-ZnO/carboxymethyl cellulose based active coating impact on ready-to-use pomegranate during cold storage. *Food Chemistry* 232:721–726.

UNDER PEER REVIEW

| Treatments | TSS ($^0$brix) | pH | Ascorbic acid (mg 100g$^{-1}$) | Titrableacidity (%) | Total sugars (%) | Reducing sugars (%) | Non reducing sugars (%) | Lycopene content (mg 100g$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **$T_1$** | 4.50 | 4.64 | 20.98 | 0.40 | 2.92 | 2.69 | 0.23 | 6.35 |
| **$T_2$** | 5.00 | 4.65 | 21.50 | 0.38 | 3.21 | 3.06 | 0.15 | 6.00 |
| **$T_3$** | 4.90 | 4.49 | 21.50 | 0.38 | 3.12 | 2.95 | 0.17 | 6.05 |
| **$T_4$** | 4.80 | 4.43 | 21.80 | 0.39 | 3.11 | 2.93 | 0.18 | 6.07 |
| **$T_5$** | 4.30 | 4.67 | 23.08 | 0.45 | 2.89 | 2.60 | 0.29 | 6.52 |
| **$T_6$** | 4.10 | 4.57 | 23.40 | 0.46 | 2.84 | 2.54 | 0.30 | 6.54 |
| **$T_7$** | 4.00 | 4.69 | 23.71 | 0.48 | 2.80 | 2.48 | 0.32 | 6.64 |
| **$T_8$** | 4.40 | 4.54 | 22.92 | 0.43 | 2.90 | 2.64 | 0.26 | 6.50 |
| **$T_9$** | 4.60 | 4.60 | 22.50 | 0.42 | 2.99 | 2.78 | 0.21 | 6.50 |
| **$T_{10}$** | 4.70 | 4.58 | 22.08 | 0.42 | 3.10 | 2.92 | 0.18 | 6.12 |
| **$T_{11}$** | 5.30 | 4.44 | 20.00 | 0.34 | 3.28 | 3.17 | 0.11 | 5.90 |
| **$T_{12}$** | 5.30 | 4.46 | 19.60 | 0.33 | 3.30 | 3.19 | 0.11 | 5.85 |
| **$T_{13}$** | 5.40 | 4.48 | 19.30 | 0.33 | 3.33 | 3.22 | 0.11 | 5.83 |
| **$T_{14}$** | 5.20 | 4.64 | 20.50 | 0.36 | 3.21 | 3.07 | 0.14 | 6.01 |
| **SEm±** | **0.12** | **0.07** | **0.36** | **0.01** | **0.05** | **0.05** | **0.004** | **0.07** |
| **CD** | **0.34** | **NS** | **1.03** | **0.02** | **0.15** | **0.13** | **0.01** | **0.21** |

UNDER PEER REVIEW

| (P=0.05) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|

Table 1. Effect of foliar spraying of nano ZnO on physiological loss in TSS, pH, ascorbic acid, titrable acidity, total sugars, reducing sugars non- reducing sugars and lycopene content of tomato grown in polybags.

| | **Physiological loss in weight (%)** | | | | | |
|---|---|---|---|---|---|---|
| **Treatments** | **3rd day after harvesting** | **6th day after harvesting** | **9th day after harvesting** | **12th day after harvesting** | **Shelf life (days)** | **Firmness (kg $cm^{-2}$)** |
| **$T_1$** | 3.89 | 7.02 | 10.05 | * | 10.63 | 2.70 |
| **$T_2$** | 4.11 | 7.75 | 10.82 | * | 10.03 | 2.22 |
| **$T_3$** | 4.06 | 7.58 | 10.54 | * | 10.23 | 2.32 |
| **$T_4$** | 4.02 | 7.27 | 10.12 | * | 10.43 | 2.41 |
| **$T_5$** | 3.74 | 6.70 | 9.05 | * | 11.33 | 2.91 |
| **$T_6$** | 3.71 | 6.59 | 8.84 | * | 11.50 | 3.00 |
| **$T_7$** | 3.64 | 6.36 | 8.51 | * | 11.67 | 3.05 |
| **$T_8$** | 3.82 | 6.78 | 9.13 | * | 11.03 | 2.86 |
| **$T_9$** | 3.92 | 7.02 | 9.51 | * | 10.60 | 2.70 |
| **$T_{10}$** | 3.94 | 7.12 | 9.84 | * | 10.33 | 2.51 |

UNDER PEER REVIEW

| | | | | | | |
|---|---|---|---|---|---|---|
| **$T_{11}$** | 4.19 | 8.18 | * | * | 9.23 | 2.00 |
| **$T_{12}$** | 4.22 | 8.43 | * | * | 9.13 | 1.99 |
| **$T_{13}$** | 4.24 | 8.57 | * | * | 9.00 | 1.90 |
| **$T_{14}$** | 4.15 | 7.95 | * | * | 9.50 | 2.14 |
| **SEm±** | **0.05** | **0.11** | **0.16** | | **0.35** | **0.05** |
| **CD (P=0.05)** | **0.13** | **0.33** | **0.46** | | **1.02** | **0.13** |

Table 2. Effect of foliar spraying of nano ZnO on physiological loss in weight (%) at 3$^{rd}$, 6$^{th}$, 9$^{th}$ and 12$^{th}$ day after harvesting, shelf life and firmness of tomato grown in polybags.

UNDER PEER REVIEW