Response of Manfalouty and Hejazy pomegranate cultivars to conventional and Nano Zinc oxide foliar application

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Abstract

Recently, there has been interest in substituting ordinary mineral equivalents with nanoparticles (NPs), notably those derived from micronutrients. This experiment was carried out during two progressive seasons of 2021 and 2022 on 45 years-old Manfalouty and Hejazy pomegranate cultivars grown in the research orchard and laboratories of Pomology department, faculty of agriculture, Assiut university, Egypt. The aim of this study was to evaluate the effect of Nano & conventional Zinc oxide and their comparative efficacy on fruit quality and marketable yield. Zinc Oxide conventional and nanoparticle (ZnO NPs) with two concentrations of each other (15 and 25 ppm), two sources of Zinc Oxide were sprayed twice (first: at full bloom and the second after a month from the first one). Results showed that Nano Zinc at 15 and 25 ppm led to a significant improvement in almost studied characters (leaf area, fruit, arils and rind weight, juice volume, TSS, TSS/ acid, reducing sugars and total acidity percentage in fruit juice).

Keywords : Nano fertilizers; micronutrients; Punica granatum.

1. Introduction

One of the edible fruit crops and one of the most important in terms of commerce is the pomegranate (Punica granatum L.). It is a Punicaceae fruit tree that is primarily grown in subtropical and tropical climates (Adsule and Patil, 1995; Naik and Chand, 2011). Consumed either processed or fresh, pomegranate fruits offer a good amount of antioxidant components and a balanced cuisine for jams, jellies, syrups, and juices (Legua et al., 2012). Pomegranate could also be ingested in its refined state (Alighourchi et al., 2008). Fruit quality and production can be impacted by minerals both directly and indirectly (Al-hadrawi and Al-janabi, 2020). According to Dong et al. (2005), the most crucial objective in agricultural systems is to use fertilizers effectively to increase crop output. Nevertheless, it can be difficult to match fertilizer supply to crop needs. Due to the ability of plant leaf canopy to absorb nutrients, foliar spraying of fertilizers has become a widespread practise for feeding plants with nutrients (Weinbaum, 1988). Several crops experience deficits of zinc (Zn), one of the crucial and fundamental minerals for plants (Swietlik, 1999; Marschner, 2012; Ojeda-Barrios et al., 2014). Cell division, photosynthesis, tryptophan synthesis, and membrane structure preservation are all aided by it. Moreover, it serves as a cofactor regulator for a certain protein's synthesis. It is required for a number of enzymatic processes, including those involving aldolases, transphosphorylases, dehydrogenases, and polymerases of RNA and DNA (Marschner, 2012).

Commercial chemical fertilizers have been connected to a number of problems, such as loss of biodiversity, eutrophication, soil acidification, and groundwater and air pollution (Kourgialas et
Alalaf et al. (2020) issued that foliar spraying with chelated zinc fertilizer recorded a significant increase in the seedling diameter and the zinc content of the leaves, while there were no significant differences between all the fertilizer treatments, including the comparison treatment with the leaves content of phosphorous and potassium of seedlings of Citrus grandis grafted onto the rootstock of Sour orange.

El-Hak et al. (2019) found that spraying grape vines with 0.4 ppm nano-zinc increased significantly leaf area and fresh weight compared with the control, while 1.2 ppm nano-zinc increased significantly total carbohydrate, leaf concentration of Fe, No. of clusters, cluster weight and yield. Also results showed that 0.4, 0.8 and 1.2 ppm of nano-zinc had a significant increase on yield of flame seedless grapevine cultivar compared with conventional fertilizer.

The aim of this study was to evaluate and compare the effects of foliar spraying two pomegranate cultivars with traditional and Nano zinc oxide.

2. Materials and methods

2.1. Experiment site
The current experiment was conducted during two progressive seasons of 2021 and 2022 on Manfalouty and Hejazy pomegranate cultivars grown in the research orchard and laboratories of Pomology department, faculty of agriculture, Assiut, Egypt.

2.2. Plant Materials
Thirty healthy 45 years-old pomegranate trees of the two studied cultivars (15 trees for each cultivar, 3 trees/treatment) were chosen in a complete randomized block design to execute the following treatments:

1- Zinc oxide (conventional) at 15 ppm
2- Zinc oxide (conventional) at 25 ppm
3- Zinc oxide (Nano) at 15 ppm
4- Zinc oxide (Nano) at 25 ppm
5- Control (water only)

Trees were sprayed using a Knapsack sprayer (20 L). A total volume of 5 lit. was sufficient for each tree at maximum growth. A surfactant "liquid soap" at 0.5 ml/L. was added to the spraying solutions. The spraying compounds were added two times: at full bloom (mid-May) and one month later. Each treatment consisted of 3 trees (experimental units or replicates). common horticultural practices on orchard such as (irrigation and fertilization) were done except those dealt with zinc oxide.

2.3. Vegetative measurement

Leaf area (cm²): was measured by using the following equation as mentioned by Ahmed and Morsy (1999)

Leaf area (cm²) = 0.41 (Length of leaf x Width of leaf) + 1.83

2.4. Physical characteristics

1- Fruit, arils and rind weight (g): by using sensitivity balance with 0.01g accuracy
2- Juice volume (ml): by using a measuring cylinder

2.5. Chemical characters

1- Total soluble solids (TSS %): By using a hand refractometer (ATAGO N-IE).

The total acidity was expressed as Citric acid according to the following equation:

\[ \text{Acidity (\%)} = \frac{\text{NaOH volume used in titration} \times \text{NaOH molarity} \times \text{equivalent weight of Citric acid}}{1000 \times \text{sample volume}} \times 100 \]

Where:
Equivalent weight of Citric acid = 64
NaOH molarity = 0.1M
Sample Vol. = 5 ml.
3- TSS / acid ratio was then calculated.

3.1. Leaf area (cm²), fruit and arils weight (g):
Leaf area increased significantly compared to the control (Table 1). Zinc oxide (Nano) at 25 ppm recorded the highest values of leaf area (cm²) of Manfalouty and Hejazy Pomegranate cultivars (11.36, 12.25 and 12.22, 12.11 cm²) compared to the check treatment which recorded the lowest values (10.38, 10.41 and 9.79, 10.17 cm²) during 2021 and 2022 seasons, respectively.

Fruit weight take the same trend of leaf area and increased significantly compared to the control where Zinc oxide (Nano) at 25 ppm recorded the highest values of leaf area (cm²) of Manfalouty and Hejazy Pomegranate cultivars (403.1, 404.9 and 433.0, 408.0 g) compared to the check treatment which recorded the lowest values (315.9, 314.1 and 307.2, 313.3 g) during the two seasons, respectively.

These results were concomitant with those found by El-Hak El., et al., (2019) on Flame seedless grapevine cultivar.
Table 1. Effect of foliar application with conventional and Nano Zinc oxide on leaf area, fruit weight and arils weight of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cultivars</th>
<th>2021 (Manfalouty)</th>
<th>2022 (Manfalouty)</th>
<th>2021 (Hejazy)</th>
<th>2022 (Hejazy)</th>
<th>2021 (Manfalouty)</th>
<th>2022 (Manfalouty)</th>
<th>2021 (Hejazy)</th>
<th>2022 (Hejazy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc oxide (conventional) at 15 ppm</td>
<td>Manfalouty</td>
<td>10.98</td>
<td>11.71</td>
<td>10.51</td>
<td>369.8</td>
<td>382.6</td>
<td>412.1</td>
<td>367.4</td>
<td>247.9</td>
</tr>
<tr>
<td></td>
<td>Hejazy</td>
<td>10.85</td>
<td>10.49</td>
<td>10.46</td>
<td>381.4</td>
<td>370.2</td>
<td>401.9</td>
<td>382.5</td>
<td>254.7</td>
</tr>
<tr>
<td>Zinc oxide (conventional) at 25 ppm</td>
<td>Manfalouty</td>
<td>11.14</td>
<td>10.95</td>
<td>10.46</td>
<td>381.4</td>
<td>370.2</td>
<td>401.9</td>
<td>382.5</td>
<td>254.7</td>
</tr>
<tr>
<td></td>
<td>Hejazy</td>
<td>10.49</td>
<td>10.95</td>
<td>10.46</td>
<td>381.4</td>
<td>370.2</td>
<td>401.9</td>
<td>382.5</td>
<td>254.7</td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 15 ppm</td>
<td>Manfalouty</td>
<td>11.26</td>
<td>10.45</td>
<td>11.21</td>
<td>344.7</td>
<td>373.6</td>
<td>372.2</td>
<td>370.8</td>
<td>217.8</td>
</tr>
<tr>
<td></td>
<td>Hejazy</td>
<td>11.31</td>
<td>10.45</td>
<td>11.21</td>
<td>344.7</td>
<td>373.6</td>
<td>372.2</td>
<td>370.8</td>
<td>217.8</td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 25 ppm</td>
<td>Manfalouty</td>
<td>11.36</td>
<td>12.22</td>
<td>12.11</td>
<td>403.1</td>
<td>404.9</td>
<td>433</td>
<td>408</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>Hejazy</td>
<td>12.25</td>
<td>12.22</td>
<td>12.11</td>
<td>403.1</td>
<td>404.9</td>
<td>433</td>
<td>408</td>
<td>231</td>
</tr>
<tr>
<td>Control (water only)</td>
<td>Manfalouty</td>
<td>10.38</td>
<td>9.79</td>
<td>10.17</td>
<td>315.9</td>
<td>314.1</td>
<td>307.2</td>
<td>313.3</td>
<td>205.7</td>
</tr>
<tr>
<td></td>
<td>Hejazy</td>
<td>10.41</td>
<td>9.79</td>
<td>10.17</td>
<td>315.9</td>
<td>314.1</td>
<td>307.2</td>
<td>313.3</td>
<td>205.7</td>
</tr>
</tbody>
</table>

L.S.D 0.05:

- Leaf area (cm2): 0.51
- Fruit weight (g): 23.1
- Arils weight (g): 12.08

Figure 1. Effect of foliar application with conventional and Nano Zinc oxide on leaf area, fruit weight and arils weight of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.
Arils weight also increased significantly compared to the control. Zinc oxide (conventional) at 25 ppm and Zinc oxide (Nano) at 25 ppm recorded the highest values of arils weight (g) of Manfalouty Pomegranate cultivar (254.7 and 256.8 g) compared to the check treatment which recorded the lowest values (205.7 and 214.7 g) during the two seasons, respectively. For the same respect, spraying Zinc oxide (Nano) at 25 ppm recorded the highest value for Hejazy cultivar (288.8, 264.7 g) compared to the check treatment which gave the lowest values (201.9, 208.2 g) during the two seasons, respectively. Otherwise, Davarpanah et al. (2016) found non-significant impact on fruit physical properties.

3.2. Rind weight (g), juice volume (ml) and TSS (%)

Data in table (2) indicated that rind weight increased significantly compared to the control. Zinc oxide (Nano) at 25 ppm and Zinc oxide (Nano) at 15 ppm recorded the highest values of rind weight (g) of Manfalouty Pomegranate cultivar (172.1 and 148.1 g) compared to the check treatment which recorded the lowest values (110.2 and 148.1 g) during the two seasons, respectively.

For the same respect, spraying Zinc oxide (conventional) at 15 ppm recorded the highest values for Hejazy cultivar (236.9 and 217.4 ml) compared to the check treatment which gave the lowest values (155.5 and 107.6 ml) during the two seasons, respectively. Juice volume take the same trend of arils weight, as it increased significantly compared to the control. Zinc oxide (conventional) at 25 ppm and Zinc oxide (Nano) at 25 ppm recorded the highest values for Manfalouty Pomegranate cultivar (17.16 and 17.13 %) compared to the check treatment which gave the lowest values (16.73 and 16.71 %) during the two seasons, respectively. Where spraying Zinc oxide (Nano) at 15 ppm and Zinc oxide (conventional)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Rind weight (g)</th>
<th>Juice volume (ml)</th>
<th>TSS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manfalouty 2021</td>
<td>Hejazy 2021</td>
<td>Hejazy 2021</td>
</tr>
<tr>
<td>Zinc oxide (conventional) at 15 ppm</td>
<td>121.9</td>
<td>135.6</td>
<td>154.4</td>
</tr>
<tr>
<td></td>
<td>196.8</td>
<td>190.7</td>
<td>212.7</td>
</tr>
<tr>
<td></td>
<td>188.5</td>
<td>17.16</td>
<td>17.13</td>
</tr>
<tr>
<td></td>
<td>17.00</td>
<td>17.11</td>
<td></td>
</tr>
<tr>
<td>Zinc oxide (conventional) at 25 ppm</td>
<td>126.7</td>
<td>117.1</td>
<td>130.7</td>
</tr>
<tr>
<td></td>
<td>213.6</td>
<td>197.6</td>
<td>220.6</td>
</tr>
<tr>
<td></td>
<td>197.6</td>
<td>17.02</td>
<td>17.12</td>
</tr>
<tr>
<td></td>
<td>17.11</td>
<td>17.13</td>
<td></td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 15 ppm</td>
<td>126.9</td>
<td>133.9</td>
<td>140.9</td>
</tr>
<tr>
<td></td>
<td>161.3</td>
<td>188.0</td>
<td>189.5</td>
</tr>
<tr>
<td></td>
<td>191.5</td>
<td>16.98</td>
<td>17.09</td>
</tr>
<tr>
<td></td>
<td>17.13</td>
<td>17.12</td>
<td></td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 25 ppm</td>
<td>172.1</td>
<td>148.1</td>
<td>144.2</td>
</tr>
<tr>
<td></td>
<td>187.7</td>
<td>215.0</td>
<td>236.9</td>
</tr>
<tr>
<td></td>
<td>217.4</td>
<td>17.11</td>
<td>17.11</td>
</tr>
<tr>
<td></td>
<td>17.10</td>
<td>17.09</td>
<td></td>
</tr>
<tr>
<td>Control (water only)</td>
<td>110.2</td>
<td>99.4</td>
<td>105.3</td>
</tr>
<tr>
<td></td>
<td>154.5</td>
<td>158.3</td>
<td>107.6</td>
</tr>
<tr>
<td></td>
<td>16.73</td>
<td>16.71</td>
<td>16.73</td>
</tr>
<tr>
<td></td>
<td>17.00</td>
<td>16.73</td>
<td></td>
</tr>
<tr>
<td>L.S.D 0.05</td>
<td>10.3</td>
<td>15.2</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>5.7</td>
<td>19.8</td>
<td>31.7</td>
</tr>
<tr>
<td></td>
<td>61.3</td>
<td>0.23</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>0.06</td>
<td></td>
</tr>
</tbody>
</table>

Likewise, TSS increased significantly compared to the control. spraying Zinc oxide (conventional) at 15 ppm recorded the highest values for Manfalouty cultivar (17.16 and 17.13 %) compared to the check treatment which gave the lowest values (16.73 and 16.71 %) during the two seasons, respectively. Where spraying Zinc oxide (Nano) at 15 ppm and Zinc oxide (conventional)
at 25 ppm recorded the highest values for Hejazy cultivar (17.13 % for each treatment) compared to the check treatment which gave the lowest values (16.73 and 17.00 %) during the two seasons, respectively. This finding matches the result reported by Davarpanah et al. (2016).

![Rind weight (g)](image1)
![Juice volume (ml)](image2)
![TSS (%)](image3)

**Figure 2.** Effect of foliar application with conventional and Nano Zinc oxide on rind weight, juice volume and TSS of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

### 3.3. Acidity (%), TSS/acid and reducing sugars (%)

Data in (Table 3) showed that acidity decreased significantly compared to the control. Zinc oxide (Nano) at 15 ppm recorded the lowest values of Manfalouty and Hejazy Pomegranate cultivars (0.36, 0.42 and 0.43, 0.46 %) compared to the check treatment which recorded the highest values (0.53, 0.56 and 0.56, 0.59 %) during 2021 and 2022 seasons, respectively. This finding matches the result reported by Davarpanah et al. (2016), TSS/acid take the same trend of acidity, whereas it increased significantly compared to the control, where Zinc oxide (Nano) at 15 ppm recorded the highest values of Manfalouty and Hejazy Pomegranate cultivars (47.17, 40.69 and 39.84, 37.22) compared to the check treatment which recorded the lowest values (31.57, 29.84 and 29.88, 28.81) during 2021 and 2022 seasons, respectively.
Table 3. Effect of foliar application with conventional and Nano Zinc oxide on acidity, TSS/ acid and reducing sugars of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Acidity (%)</th>
<th>TSS/ acid</th>
<th>Reducing sugars (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc oxide (conventional) at 15 ppm</td>
<td>0.40</td>
<td>0.45</td>
<td>0.44</td>
</tr>
<tr>
<td>Zinc oxide (conventional) at 25 ppm</td>
<td>0.39</td>
<td>0.44</td>
<td>0.45</td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 15 ppm</td>
<td>0.36</td>
<td>0.42</td>
<td>0.43</td>
</tr>
<tr>
<td>Zinc oxide (Nano) at 25 ppm</td>
<td>0.38</td>
<td>0.43</td>
<td>0.44</td>
</tr>
<tr>
<td>Control (water only)</td>
<td>0.53</td>
<td>0.56</td>
<td>0.56</td>
</tr>
<tr>
<td>L.S.D 0.05</td>
<td>0.21</td>
<td>0.12</td>
<td>0.10</td>
</tr>
</tbody>
</table>

The values shown are means of Three replicates (3 samples/each replicate).

Figure 3. Effect of foliar application with conventional and Nano Zinc oxide on acidity, TSS/ acid and reducing sugars of Manfalouty and Hejazy Pomegranate trees during 2021 and 2022 seasons.
This finding matches the result reported by Davarpanah et al. (2016), 
Reducing sugars, also, increased significantly compared to the control. Zinc oxide (conventional) at 15 ppm recorded the highest values for Manfalouty Pomegranate cultivar (10.13 and 10.11 %) compared to the check treatment which recorded the lowest values (9.56 and 9.55 %) during the two seasons, respectively. For the same respect, spraying Zinc oxide (Nano) at 25 ppm and Zinc oxide (Nano) at 15 ppm recorded the highest values for Hejazy cultivar (10.12 and 10.13 %) compared to the check treatment which gave the lowest values (9.56 and 9.70 %) during the two seasons, respectively.

4. Discussion

Reactivity, uncommon surface area, and size of zinc nanoparticulate particles promote zinc solubility, diffusion, and accessibility to plants, making zinc fertilizers new nanomaterials that can be employed to construct plant components (Subramanian et al., 2015; Mosanna and Behrozyar, 2015). Zinc is one of the important nutrients for plants, and many crops frequently lack it (Swietlik, 1999; Marschner, 2012; Ojeda-Barrios et al., 2014). In addition, several enzymes, including transphosphorylases, dehydrogenases, isomerases, and aldolases, often need a specific quantity of Zn in the cellular environment to work. The manufacture of tryptophan, DNA and RNA polymerases, membrane structure maintenance, cell division, and photosynthesis are all processes that tryptophan is engaged in. Zn is also a regulatory co-factor in protein biosynthesis (Marschner, 2012). According to past observations, zinc foliar sprays have increased the productivity and number of fruits on pomegranate trees.

During the creation and blossoming of fruit buds, zinc functions in the synthesis of tryptophan, an auxin precursor, and the transfer of metabolites to the site of bud growth or to the bud itself (Swietlik, 1999; Usenik and Stampar, 2002), (Day, 1994; Ryugo, 1988). Increases in TSS in apple fruits fertilized with Zn have previously been connected to Zn’s effects on carbohydrate synthesis and translocation (Yogeratnam and Greenham, 1982). Whereas Zn’s effects on total sugars can be linked to its function in starch and nucleic acid metabolism as well as the activity of numerous enzymes engaged in these biochemical steps, B’s effects on total sugars can be related to B’s roles in sugar transport and carbohydrate metabolism (Alloway, 2008), (Hansch and Mendel, 2009).

5. Conclusion

It could be concluded that Nano Zinc at 15 and 25 ppm led to a significant improvement in almost studied characters (leaf area, fruit, arils and rind weight, juice volume, TSS, TSS/ acid, reducing sugars and total acidity percentage in fruit juice).

Funding
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Institutional Review Board Statement
All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement
Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate
Not applicable

Consent for Publication
Not applicable.

Conflicts of Interest
The author disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

6. References


