GROWTH, YIELD AND QUALITY AS AFFECTED BY NANOCHITOSAN AND BIOCAPSULES IN KINNOW MANDARIN (CITRUS RETICULATA)

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Key words: Kinnow, Nanochitosan, Biocapsule, Soil drenching, NPK.

Abstract—The present study was carried out in the Research field of the Department of Horticulture, SHUATS, Prayagraj, UP, India. The experiment was conducted in Randomized Block Design (RBD) having 9 treatments, with three replications. Among all the treatments T6 NPK (RDF)+ Nanochitosan 100 ppm (soil drenching)+ Biocapsule 500 ppm (Soil drenching) was observed best in the terms of yield parameters like maximum plant height (3.96m), Maximum number of flower per plant (166.26), Maximum number of fruit per plant (142.65), Maximum fruit diameter (7.89 cm), the maximum fruit weight (136.49 g), The maximum yield per plant (20.15 kg), Maximum fruit yield (53.72 t ha⁻¹), and Qualitative parameters like Maximum TSS (10.43), Acidity% (1.08), Ascorbic acid (27.43 mg), Reducing sugar (3.73%), Non Reducing sugar (5.15%) and Total sugar (8.88%). The influence of Biocapsules and nanochitosan with combination of NPK (RDF) not only increase the yield parameters but also maintained the qualitative parameters by the action of anti-pathogen effect and nutrient fixation in Kinnow plant.

INTRODUCTION

Kinnow is a high yield mandarin hybrid (Citrus nobilis × Citrus deliciosa), scientifically known as Citrus reticulata blanco. Botanically kinnow belongs to family Rutaceae. Kinnow is renowned citrus fruit favored for its pleasant flavor, appearance, color, taste, good yield, high processing value, therapeutic applications, delicious juice, smoothing character, vitamin C source, wider adaptability to various agro-climatic condition and high nutritive value. Kinnow is a hybrid of two citrus cultivars ‘king’ (Citrus nobilis) and ‘willow leaf’ (Citrus deliciosa). It was developed by H.B Frost in 1915 at University of California Citrus Experimentation Station, USA. The hybrid was released for commercial cultivation in 1935. Kinnow was introduced in India by Dr. J.C Baksh in 1954 at Punjab Agriculture University Regional Research Station, Abohar. Since its introduction, Kinnow has gained popularity among farmers and common people making it one of the most desirable citrus fruit in Punjab. Kinnow mandarin (Citrus reticulata Blanco) belongs to family Rutaceae. It is one of the most popular fruit among different citrus species. Kinnow mandarin, a hybrid between King Mandarin (Citrus nobilis Lour) and Willow leaf mandarin (Citrus deliciosa Tenore) is the most important commercial cultivar of Citrus in Northern India. It was developed by H. B. Frost at California Citrus station in 1951 and was introduced in Punjab in 1966. In India citrus are mainly cultivated in four zones viz. central India (Gujarat, Madhya Pradesh and Maharashtra), north-eastern India (Assam, Meghalaya and Sikkim), southern India (Karnataka and Andhra Pradesh), and north-western India (Haryana, Punjab, western UP and Rajasthan). Different zones have specific leading cultivar which represents their respective area (Etebu and Nwauzoma, 2014). These crops play an important role in the economy of our country and hold third position in fruit industry of India, NHB database (2016) but their yield levels are very low (Srivastava and Singh, 2009). Citrus is a leading fruit crop in the world and third leading crop in India after mango and banana. Yield of these crops depend on several abiotic (soil, nutrition, site,
climate and irrigation management) and biotic (cultivar, rootstock, disease and pest management) factors (Davies and Albrigo, 1994; Iglesias et al., 2007). The annual fertilizer application rate, timing and its placement are the pre-requisite to enhance nutrient uptake efficiency and to reduce nutrient losses (Tucker et al., 1995).

Nanochitosan has broad antimicrobial activity against fungal pathogens however, the bulk size limits its solubility which affects the antimicrobial properly, chitosan man particles have great potential over the bulk counter parts as size can alter several properties compare to bulk materials. The exclusive properties of these materials, such as a large surface area and greater reactivity, have also raised concerns about adverse effect on environmental health.

MATERIALS AND METHODS

The experiment was carried out on 5 years old Kinnow plant at the Central Research filed of Department of Horticulture, SHUATS, Prayagraj, Uttar Pradesh, during 2021-2022. The experiment was conducted in RBD having 9 treatments namely T1 NPK (RDF), T2 500 ppm (Soil drenching), T3 Biocapsule 50 ppm (Soil drenching), T4 Nanochitosan 100 ppm (soil drenching), T5 Nanochitosan 50 ppm (Soil drenching), T6 NPK (RDF) + Nanochitosan 100 ppm (soil drenching)+ Biocapsule 500 ppm (Soil drenching), T7 NPK (RDF) + Biocapsule 250 ppm (soil drenching) + Nanochitosan 50 ppm, T8 NPK (RDF) + Biocapsule 500 ppm (Soil drenching) and T9 NPK(RDF)+ Nanochitosan 100 ppm (Soil drenching), with three replications.

Preparation of Biocapsules solution

Biocapsules were purchased from the ICAR licensed company CADAGU Agritech. Karnataka. Each biocapsules having 1 g wgt. or 1000 ppm concentration and the ability of dissolving in 100 l of water. So according to the concentration capsules are first dissolved in 1 l of lake warm water before 12 hours of application and then after that 1 l of solution was dissolve in 50 l (for 500 ppm) and 25 ltr. (for 250 ppm) of water. After that Kinnow plants were drenched with 1 l of that solution. The biocapsule drenching were applied at different interval during the research.

Preparation of Nanochitosan solution

Nanochitosan were purchased from the Nano research element Haryana. According to their concentration of ppm they are first dissolved in the 5 ml ethyl alchohol solution after that it dissolves in the 1 l of water and then drenched in the Kinnow plant. The Nanochitosan drenching were applied at different interval during the research.

RESULTS AND DISCUSSION

Growth parameters

The maximum plant height (2.87, 3.05, 3.23, 3.34, 3.55, 3.69, 3.82 and 3.96 m) at 30, 60, 90, 120, 150, 180, and 210, DAT was found in T6 followed by T8. However minimum plant height (2.34, 2.44, 2.57, 2.72, 2.91, 3.13, 3.22, 3.37, and 3.49) 30, 60, 90, 120, 150, 180, and 210 DAT was recorded T2. The increment in plant height might be affected by the drenching of Biocapsules with combination of NPK(RDF), that have the ability of fixing the nutrient like nitrogen and phosphorus in the root of Kinnow plant. Similar results were given by Tsugita et al. (2013).

The maximum number of branches per plant (43.41) was recorded with the T6. Whereas the minimum number of branches per plant (30.07) was found in T5. Due to the effect of Biocapsules and nanochitosan with combination of NPK, the maximum number of branches observed in that particular treatments. Similar results were given by Tsugita et al. (2013).

Yield parameters

The maximum number of flowers per plant (166.26) was recorded with the T6. Whereas the minimum number of flowers per plant (107.87) was found in T5. The obtained results are in agreement with Mondale et al., (2013)

The maximum number of fruits per plant (142.65) was recorded with the T6. Whereas the minimum number of fruits per plant (95.59) was found in T5 Nanochitosan 50 ppm. The obtained results are in agreement with Mondal et al., (2013)

The maximum fruit weight (g) (136.49) was recorded with the T6. Whereas the minimum fruit weight (g) (99.74) was found in T5. The obtained results are in agreement with Gayed et al. (2017)

The maximum fruit yield per plant (kg) (19.39) was recorded with the T6. Whereas the minimum fruit yield per plant (kg) (9.53) was found in T5 Nanochitosan 50 ppm. The obtained results are in agreement with Gayed et al. (2017)

The maximum fruit yield (t ha⁻¹) (53.72) was
recorded with the T_6. Whereas the minimum fruit yield (t ha\(^{-1}\)) (26.41) was found in T_5. The obtained results are in agreement with Gayed et al. (2017).

The maximum fruit diameter (cm) (7.89) was recorded with the T_6. Whereas the minimum fruit diameter (cm) (6.22) was found in T_5. The obtained results are in agreement with Gayed et al. (2017).

The maximum fruit length (cm) (6.67) was recorded with the T_6. Whereas the minimum fruit length (cm) (4.45) was found in T_5. The obtained results are in agreement with Gayed et al. (2017).

**Quality parameters**

The maximum Total soluble solid (10.43 °B) was recorded with the T_6. Whereas the minimum Total soluble solid (9.40 °B) was found in T_5. Nano-chitosan has played an important role in improving soluble solid content and also helped maintain the post-harvest firmness of the fruit. The obtained results are in agreement with Giacalone and Chiabrando (2013).

The maximum Ascorbic acid (27.43 mg) was recorded with the T_6. Whereas the minimum Ascorbic acid (21.80 mg) was found in T_5. Nano-chitosan improved the ascorbic acid and also helped maintain the post-harvest firmness of the fruit. The obtained results are in agreement with Giacalone and Chiabrando (2013).

The maximum Acidity (1.08 %) was recorded with the T_6. Whereas the minimum Acidity (0.91%) was found in T_5. Nano-chitosan with combination of Biocapsules and NPK improved the acidity and also helped maintain the post-harvest firmness of the fruit. Therefore, the difference was significant, indicating a significant effect of Nanochitosan and Biocapsules different treatment combination on Acidity (% of Kinnow mandarin (Citrus reticulata)). The obtained results are in agreement with Giacalone and Chiabrando (2013).

The maximum reducing sugar (3.73%) was recorded with the T_6. Whereas the minimum reducing sugar (2.44%) was found in T_5. Nano-chitosan improved the reducing sugar and also helped maintain the post-harvest firmness of the fruit. Therefore, the difference was significant, indicating a significant effect of Nanochitosan and Biocapsules different treatment combination on Reducing sugar (%) of Kinnow mandarin (Citrus reticulata). The obtained results are in agreement with Giacalone and Chiabrando (2013).

The maximum non-reducing sugars (5.15%) was recorded with the T_6. Whereas the minimum non-reducing sugars (3.86%) was found in T_5. Nano-chitosan improved the non-reducing sugars and also helped maintain the post-harvest firmness of the fruit. Therefore, the difference was significant, indicating a significant effect of Nanochitosan and Biocapsules different treatment combination on Non-reducing sugar (%) of Kinnow mandarin (Citrus reticulata). The obtained results are in agreement with Giacalone and Chiabrando (2013).

**Table 1. Growth, Yield and Quality as affected by Nanochitosan & Biocapsules in Kinnow mandarin (Citrus reticulata)**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (m)</th>
<th>Number of branches Per plant</th>
<th>Number of flowers per plant</th>
<th>Number of fruits per plant</th>
<th>Fruit weight (g)</th>
<th>Fruit yield per plant (kg)</th>
<th>Fruit length (cm)</th>
<th>Number of seed per fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3.74</td>
<td>39.19</td>
<td>130.46</td>
<td>111.32</td>
<td>116.36</td>
<td>12.95</td>
<td>5.60</td>
<td>25.60</td>
</tr>
<tr>
<td>T2</td>
<td>3.49</td>
<td>35.63</td>
<td>132.32</td>
<td>115.48</td>
<td>101.73</td>
<td>11.76</td>
<td>5.45</td>
<td>21.75</td>
</tr>
<tr>
<td>T3</td>
<td>3.68</td>
<td>35.40</td>
<td>124.83</td>
<td>119.15</td>
<td>105.71</td>
<td>12.16</td>
<td>5.75</td>
<td>25.30</td>
</tr>
<tr>
<td>T4</td>
<td>3.52</td>
<td>38.52</td>
<td>132.08</td>
<td>117.90</td>
<td>102.89</td>
<td>12.13</td>
<td>5.61</td>
<td>25.65</td>
</tr>
<tr>
<td>T5</td>
<td>3.39</td>
<td>30.07</td>
<td>107.87</td>
<td>95.59</td>
<td>99.74</td>
<td>7.66</td>
<td>4.45</td>
<td>18.68</td>
</tr>
<tr>
<td>T6</td>
<td>3.96</td>
<td>43.41</td>
<td>166.26</td>
<td>142.65</td>
<td>136.49</td>
<td>20.15</td>
<td>6.67</td>
<td>24.62</td>
</tr>
<tr>
<td>T7</td>
<td>3.73</td>
<td>42.67</td>
<td>162.48</td>
<td>130.27</td>
<td>125.21</td>
<td>16.31</td>
<td>6.03</td>
<td>25.42</td>
</tr>
<tr>
<td>T8</td>
<td>3.82</td>
<td>38.26</td>
<td>145.07</td>
<td>120.21</td>
<td>107.73</td>
<td>12.94</td>
<td>6.21</td>
<td>25.29</td>
</tr>
<tr>
<td>T9</td>
<td>3.73</td>
<td>38.30</td>
<td>145.37</td>
<td>121.77</td>
<td>106.51</td>
<td>12.97</td>
<td>5.61</td>
<td>25.14</td>
</tr>
<tr>
<td>F test</td>
<td>S S</td>
<td>S S</td>
<td>S S</td>
<td>S S S</td>
<td>5.57</td>
<td>5.826</td>
<td>0.773</td>
<td>0.227</td>
</tr>
<tr>
<td>C.D. at 0.5%</td>
<td>0.051</td>
<td>1.339</td>
<td>5.375</td>
<td>5.570</td>
<td>5.826</td>
<td>0.773</td>
<td>0.227</td>
<td>0.812</td>
</tr>
<tr>
<td>S. Ed. (±)</td>
<td>0.108</td>
<td>2.829</td>
<td>11.395</td>
<td>11.808</td>
<td>12.350</td>
<td>1.638</td>
<td>0.480</td>
<td>1.720</td>
</tr>
</tbody>
</table>
The maximum total sugars (8.88%) was recorded with the T6. Whereas the minimum total sugars (6.29%) was found in T5. Nano-chitosan improved the Total sugar and also helped maintain the post-harvest firmness of the fruit. Therefore, the difference was significant, indicating significant effect of Nanochitosan and Biocapsules different treatment combination on Total sugar (%) of Kinnow mandarin (*Citrus reticulata*). The obtained results are in agreement with Giacalone and Chiabrando (2013).

### CONCLUSION

On the basis of results obtained, it is concluded that the T6 NPK (RDF) + Nanochitosan 100 ppm (soil drenching) + Biocapsule 500 ppm (soil drenching) was found best in terms of growth, fruit yield and quality of Kinnow mandarin (*Citrus reticulata*) under Prayagraj agro climatic condition.

### REFERENCES


