The effect of pre-harvest application of chemicals on growth, yield and post-harvest qualities of Bhendi (Abelmoschus esculentus L. Moench)

N Arthi, A Beaulah and TN Balamohan

Abstract
The field experiment was conducted at Horticulture Orchard, Agricultural College and Research Institute, Madurai, Tamil Nadu Agricultural University to study the effect of pre harvest chemicals on yield and post harvest quality parameters of bhendi. The bhendi plants were sprayed with chemicals individual as well as in combination. The results revealed that the combinational effect of CaCl$_2$ 5000ppm + GA$_3$ 50 ppm + BA 50 ppm showed the highest number of pods, pod yield, shelf life, moisture content, vitamin – C and crude fibre content. But the highest plant height was recorded in plants sprayed with GAs due to elongation of stem. The overall yield and quality aspects of bhendi has improved by the combinational effect.

Keywords: Okra, yield, shelf life, crude fibre

Introduction
Bhendi [Abelmoschus esculentus (L.) Moench] is an annual vegetable crop belongs to family Malvaceae and is originated in Africa (Shoemaker, 1942) $^{[10]}$. It is cultivated since long back and distributed from Africa to Asia, Southern Europe and America and currently grown in many tropical countries. It is popular throughout India due to its wide range adaptability for cultivation.

Bhendi is valued for its tender delicious pods and has been reported to have an average nutritious value (ANV) of 3.21 which is higher than tomato, eggplant and most of the cucurbits (Grubben, 1977) $^{[10]}$. The tender pods are canned green or dried for off season. These green pods are rich sources of vitamins, calcium, potassium and other minerals (i.e., Ca, Mg & P) (Matloob et al., 1989) $^{[10]}$, which minimize their deficiency in the daily diet. Bhendi is said to be very useful against genitourinary disorder, spermatorrhoea and chronic dysentery. High iodine content of pods helps in controlling goiter disease.

Owing to its multifolds uses, the area under bhendi cultivation is increasing rapidly. India is the largest producer and exporter of bhendi, 70% of world’s production is from India. There is an increasing demand for high quality bhendi pods, with a balanced nutrition. Even though there is demand in international markets for bhendi pods, post-harvest shelf life is very less. The growth and yield analysis in crop plants helps in understanding the contribution of various components for higher productivity. The pre harvest chemicals helps in improvement of shelf life of the produce. Hence, to reduce the spoilage and to improve the market value of the produce, the present research has been carried out with pre harvest chemicals.

Material and Methods
The present research was conducted at the College Orchard, Agricultural College and Research Institute, Madurai. Bhendi hybrid CO-4 was used for this experiment. Sowing was taken up during August to December 2018. The plants were spaced 60 cm between the rows and 30 cm within the rows. Plants were grown under drip irrigation and uniform cultural practices suitable for commercial bhendi production. The experiment comprises of eight treatments including control with three replications. Each treatment consists of 12 plants for single replication. The treatments were applied twice during 20 DAS and 40 DAS using knapsack sprayer.
Preventive measures were undertaken against the attack of shoot and fruit borer by periodical sprayings of recommended pesticides. The pods were harvested 6 days after anthesis and pods were hand picked at alternate days.

**Plant growth and yield response**
At each harvest the number of pods were counted for individual plants and total number of pods was worked out and expressed in number. The pods are weighed individually in an electronic weighing balance for recording the pod weight and expressed in gram (g). The height of the individual plant was measured by using a meter scale. The total number of pods from individual plant, at each harvest was weighed by using electronic weighing balance and expressed in kilograms (kg).

**Quality aspects of bhendi**
The pods were stored at ambient storage condition. Observations were recorded on daily basis from the date of storage. The number of hours for the pods to be with acceptable texture, appearance and physiological loss in weight and was expressed in hours. The moisture content was noted by drying the pods at 60 °C for nine hours. It was calculated by using the formula,

\[
\text{Moisture content} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100
\]

And expressed in percent (AOAC, 1997) \[1\]. The physiological loss in weight was recorded by weighing the pods on every day until loss of freshness and was calculated by using the formula, (Pila et al., 2010) \[13\].

\[
\text{Physiological loss in weight} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100
\]

The vitamin – C content and crude fibre content was also estimated by following the procedure by Ranganna (2001) \[14\].

**Experiment design and statistical analysis**
The experiment was conducted according to the Randomized Block Design (RBD) by using eight treatments, each comprising of three replications. The data gathered for each of the above parameters were subjected to analysis of variance and tested for significance (AGRES) as per Panse and Sukhatme (1995) \[18\].

**Results and Discussion**

**Effect of pre-harvest application on growth and yield parameters of bhendi**
The application of pre harvest chemicals has significantly improved the yield characters of Bhendi hybrid CO - 4 such as plant height, pod weight, number of pods per plant, yield per plant and estimated yield per hectare. The data presented in Table 2 has revealed the following results.

**Height of the plant (cm)**
The treatment T₄ = GA₃ 50 ppm has recorded the highest plant height of 119.04 cm which is on par with T₇ (CaCl₂ 5000 ppm + GA₃ 50 ppm + BA 50 ppm) of 117.56 cm. The lowest value (101.88 cm) was recorded with the treatment T₀ – control. The results are in accordance with Yamgar and Desai (1987) \[18\] in chilli and Sharma et al. (1988) in bottle gourd who reported that increase in height of the plant might be due to enhanced photosynthetic activity and efficient assimilation of photosynthetic product.

**Pod weight (g)**
The plants treated with the combinations of treatments (CaCl₂ 5000 ppm + GA₃ 50 ppm + BA 50 ppm) T₇ has recorded the highest pod weight of 17.85 g and lowest pod weight (13.57 g) was recorded in T₀ (Control). The results are in accordance with the results of Srivastava and Sachan (1971) \[17\], as increased pod fresh weight by applying plant growth regulators (IAA and GA₃) in okra. The presence of calcium in the form of calcium pectate in middle lamella of cell wall would have increased the individual pod weight, which prevent loss of moisture from the pods and ultimately yields better quality pod. This phenomenon has been well studied by Balasubramanian (2004) \[3\] in Okra.

**Number of pods per plant (numbers)**
The combination treatment (T₂) has the highest number of pods per plant (31.66) which is on par with T₄ (31.46). The lowest value of (25.53) was recorded in control T₀. The Ayyub et al. (2013) \[2\] also reported enhanced vegetative and reproductive growth of okra in response to 100 ppm of GA₃, applied after three weeks of sowing. Moreover, it can be deduced from the results that different pod characters were correlated with number of pods per plant.

**Yield per plant (g)**
The highest pod yield per plant (551.07 g) was recorded in T₇, followed by T₄ (536.25 g). Significantly the lowest pod yield per plant (338.33 g) was noticed in T₀ (Control). Increase in pod yield and contributing components in response to growth regulators (IAA, NAA, GA₃ and ethrel) was also observed by Biradar (1999) \[4\] in chilli.

**Yield per hectare (q/ha)**
The plants treated with T₇ (CaCl₂ 5000 ppm + GA₃ 50 ppm + BA 50 ppm) produced the highest (306.80 q/ha) pod yield per hectare. Whereas, the lowest (187.26 q/ha) pod yield per hectare was recorded in T₀ (Control). These results are supported by Hao & Papadopoulus (2003) \[7\] Calcium and NAA both not only increase yield of tomato by reducing the flower drop but also increase the fruit retention (Iqbal et al., 2009) \[8\].

**Quality parameters of okra**
Application of different pre harvest chemicals at different concentration has significantly improved the quality aspects of bhendi over the control. The data presented in Table 3 has revealed the following results.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Chemicals Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>Control (water spray)</td>
</tr>
<tr>
<td>T₁</td>
<td>Calcium chloride 2500 ppm</td>
</tr>
<tr>
<td>T₂</td>
<td>Calcium chloride 5000 ppm</td>
</tr>
<tr>
<td>T₃</td>
<td>Gibberellic acid 25 ppm</td>
</tr>
<tr>
<td>T₄</td>
<td>Gibberellic acid 50 ppm</td>
</tr>
<tr>
<td>T₅</td>
<td>Benzyl adenine 25 ppm</td>
</tr>
<tr>
<td>T₆</td>
<td>Benzyl adenine 50 ppm</td>
</tr>
<tr>
<td>T₇</td>
<td>CaCl₂ 5000 ppm + GA₃ 50 ppm + BA 50 ppm</td>
</tr>
</tbody>
</table>

Table 1: Treatments details

The vitamin – C content and crude fibre content was also estimated by following the procedure by Ranganna (2001) \[14\].

\[
\text{Physiological loss in weight} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100
\]

The moisture content and crude fibre content was also estimated by following the procedure by Ranganna (2001) \[14\].

The vitamin – C content and crude fibre content was also estimated by following the procedure by Ranganna (2001) \[14\].

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the plants treated with T3 (CaCl2 5000 ppm + GA3 50 ppm + BA 50 ppm) has recorded the lowest (10.36 %) physiological loss in weight in terms of percentage. Whereas, the T0 (Control) was noticed with highest loss (21.46 %) of physiological weight. The treatment T7 has the maximum shelf life of 45.66 hours, followed by T2 (42.66 hours). Significantly T0 (Control) has the minimum shelf life of 23.66 hours. However, if treated by CaCl2 before harvest, the shelf life can be extended to 14–21 days due to stimulated superoxide dismutase and peroxidase activities, lowered tissue electrolyte leakage, improved overall visual quality, and reduced microbial growth during storage (Kou et al., 2014). Regarding the Vitamin – C content, the treatment T7 showed the increased (15.76 mg/100g) vitamin – C content in the pods, followed by T2 (15.19 mg/100g). The lowest value (10.20 mg/100g) of vitamin – C content was recorded in control T0. The possible reasons might be cell wall thickening by calcium pectate and reduced rate of oxidation of ascorbic acid (Pandey and Sinha, 1999) [11]. Increased crude fibre content was noticed in the treatment T7 (8.75 %), followed by T3 (15.19 %). The lowest value (5.36 %) was recorded in T0 (Control).

### Conclusion

In conclusion, it is shown that, the combinational effect of calcium chloride 5000 ppm with gibberellic acid 50 ppm and benzyl adenine 50 ppm has given the best results compared to the individual effect of the chemicals. CaCl2 spray not only increased the absorption of calcium in leaves and pods but also enhanced the yield and shelf life of Bhendi. Gibberellic acid enhances the yield components of the plants. Benzyl adenine retards the senescence and therefore, extends the post harvest shelf life. Further study is needed to evaluate with different concentrations and application stages.

### Table 2: Effect of pre-harvest application of chemicals on growth and yield parameters of Bhendi

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Height of the plant (cm)</th>
<th>Pod weight (g)</th>
<th>Number of pods per plant (numbers)</th>
<th>Yield per plant (g)</th>
<th>Yield/ha (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 – Control</td>
<td>101.88</td>
<td>13.57</td>
<td>25.53</td>
<td>338.33</td>
<td>187.26</td>
</tr>
<tr>
<td>T1 – CaCl2 2500 ppm</td>
<td>107.40</td>
<td>17.40</td>
<td>27.73</td>
<td>466.84</td>
<td>259.35</td>
</tr>
<tr>
<td>T2 – CaCl2 5000 ppm</td>
<td>108.71</td>
<td>17.80</td>
<td>28.66</td>
<td>497.53</td>
<td>276.18</td>
</tr>
<tr>
<td>T3 – GA3 25 ppm</td>
<td>112.72</td>
<td>15.68</td>
<td>30.66</td>
<td>499.83</td>
<td>260.51</td>
</tr>
<tr>
<td>T4 – GA3 50 ppm</td>
<td>119.40</td>
<td>16.80</td>
<td>31.44</td>
<td>528.32</td>
<td>293.52</td>
</tr>
<tr>
<td>T5 – BA 25 ppm</td>
<td>105.10</td>
<td>14.87</td>
<td>25.60</td>
<td>371.81</td>
<td>206.26</td>
</tr>
<tr>
<td>T6 – BA 50 ppm</td>
<td>105.04</td>
<td>15.50</td>
<td>26.61</td>
<td>401.85</td>
<td>222.77</td>
</tr>
<tr>
<td>T7 – CaCl2 5000 ppm + GA3 50 ppm + BA 50 ppm</td>
<td>117.56</td>
<td>17.85</td>
<td>31.64</td>
<td>551.28</td>
<td>306.18</td>
</tr>
<tr>
<td>MEAN</td>
<td>109.73</td>
<td>16.18</td>
<td>28.48</td>
<td>453.22</td>
<td>238.92</td>
</tr>
<tr>
<td>S.Ed</td>
<td>2.1462</td>
<td>0.4329</td>
<td>0.1134</td>
<td>0.6230</td>
<td>0.1479</td>
</tr>
<tr>
<td>CD(0.05)</td>
<td>4.6056</td>
<td>0.9287</td>
<td>0.2432</td>
<td>1.3363</td>
<td>0.3172</td>
</tr>
</tbody>
</table>

### Table 3: Effect of pre-harvest application of chemicals on quality parameters of Bhendi

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture content (%)</th>
<th>Physiological loss in weight (%)</th>
<th>Shelf life (Number of hours)</th>
<th>Vitamin – C content (mg/100g)</th>
<th>Crude fibre content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 – Control</td>
<td>84.83</td>
<td>21.46</td>
<td>23.66</td>
<td>10.20</td>
<td>5.36</td>
</tr>
<tr>
<td>T1 – CaCl2 2500 ppm</td>
<td>87.80</td>
<td>12.39</td>
<td>37.66</td>
<td>14.78</td>
<td>7.87</td>
</tr>
<tr>
<td>T2 – CaCl2 5000 ppm</td>
<td>88.13</td>
<td>11.10</td>
<td>42.66</td>
<td>15.19</td>
<td>8.22</td>
</tr>
<tr>
<td>T3 – GA3 25 ppm</td>
<td>86.86</td>
<td>14.16</td>
<td>27.66</td>
<td>13.91</td>
<td>6.89</td>
</tr>
<tr>
<td>T4 – GA3 50 ppm</td>
<td>87.08</td>
<td>13.53</td>
<td>30.33</td>
<td>14.28</td>
<td>7.27</td>
</tr>
<tr>
<td>T5 – BA 25 ppm</td>
<td>85.50</td>
<td>17.58</td>
<td>31.66</td>
<td>11.18</td>
<td>6.03</td>
</tr>
<tr>
<td>T6 – BA 50 ppm</td>
<td>86.19</td>
<td>16.66</td>
<td>34.33</td>
<td>12.63</td>
<td>6.49</td>
</tr>
<tr>
<td>T7 – CaCl2 5000 ppm + GA3 50 ppm + BA 50 ppm</td>
<td>88.84</td>
<td>10.36</td>
<td>45.66</td>
<td>15.76</td>
<td>8.75</td>
</tr>
<tr>
<td>MEAN</td>
<td>86.90</td>
<td>14.65</td>
<td>34.20</td>
<td>13.49</td>
<td>7.11</td>
</tr>
<tr>
<td>S.Ed</td>
<td>0.0447</td>
<td>0.5673</td>
<td>0.5000</td>
<td>0.1661</td>
<td>0.0654</td>
</tr>
<tr>
<td>CD(0.05)</td>
<td>0.0958</td>
<td>1.2168</td>
<td>1.0725</td>
<td>0.3563</td>
<td>0.1403</td>
</tr>
</tbody>
</table>

### References


