Influence of pre-harvest treatments on flowering, yield and post-harvest quality of mango

Jitendra Singh Shivran, Mohan Lal Jat, Purnita Raturi, Rajkumar Jat and Rajender Kumar

Abstract
Mango (Mangifera indica L.) is one of the most delicious fruits globally, and it holds a prominent position in the global fruit processing business. Pre-harvest nutrient foliar spraying and mulching are effective techniques for extending mango flowering, yield, and post-harvest quality. During the season of 2021, the experiment was carried out in the GBPUAT experimental location in Pantnagar, Uttarakhand, India. Mulching (T1) treatment resulted in earlier panicle emergence (01-05 February), as well as early fruit set (17th March - 21st March) was found with the CaCl2 (3.0%) + mulching treatment. In terms of increasing fruit weight (156.33 g), number of fruits (280.53 fruits tree-1) and yield (43.86 kg tree-1) with treatment borax (1%) + mulching. This treatment was also found to be efficient in raising TSS (17.53 °Brix) and lowering titratable acidity (0.20%) at the end of the storage period (10th day). Similarly, total and reducing sugars were maximum when borax (1%) was applied with mulching at the end of the storage period (10th day). The treatment with CaCl2 @ 1.5 percent in combination with mulching resulted in the least physiological weight loss (15.48%) and decay loss (66.66%) at the end of the storage period, respectively. As a result of the findings, pre-harvest application of CaCl2 @ 1.5 percent with mulching is beneficial for increasing the post-harvest quality of fruits. In contrast pre-harvest application of borax @ 1.0 percent with mulching effectively improves the fruit quality of mango cv. Dashehari.

Keywords: Mulching, post-harvest quality, mango, dashehari, nutrients, foliar spray

Introduction
Mango (Mangifera indica Linn.) is a popular fruit crop that is precious worldwide for its flavour and aroma. Due to its enormous mango-growing territory, India is the world’s greatest mango producer. Mangoes were grown on an area of 2291.00 thousand hectares, yielding a total of 20,444 thousand metric tonnes (Anon., 2020) [2]. Because of its great productive capacity and outstanding fruit quality, Dashehari is a popular cultivar in north India. This variety’s fruit is primarily collected in July when the temperature and humidity are highest. Furthermore, because mango is a climacteric fruit, it must be harvested at the correct stage of maturity to avoid postharvest losses. Several pre- and post-harvest factors impact mango fruit quality and storage life, either directly or indirectly. Mulches have a significant impact on the long-term yield and quality of fruit. Raising beneficial soil bacteria enhances the physical and chemical properties of the soil and the availability of nutrient pools and biological attributes (Dutta and Majumder, 2009) [9]. Mulches provide a variety of beneficial effects, including stabilizing soil temperature, reducing water loss through evaporation, and resulting in more stored soil moisture, which is used by agricultural plants, particularly during the dry season (Shirgure et al., 2003) [28]. Mulches save soil moisture and reduce weed density by modifying soil temperature (Kaur and Kaufal, 2009) [15], resulting in higher total and early yields (Pande et al., 2005) [20]. Ghosh and Bauri, 2003 [11] reported a beneficial response to mulching on mango yield. Calcium spraying boosted mango productivity by reducing the establishment of abscission layers (Kumar et al., 2006) [17]. Throughout development, calcium supplementation to fresh fruits is a safe way to complement endogenous calcium (Raese and Drake, 2000) [23]. Many biochemical and physiological activities, including growth, yield, and quality, rely heavily on potassium (Cakmak, 2005; Pettigrew, 2008) [6·22]. Boron improves sugar translocation, cell wall synthesis and structure, and lignifications, all of which affect fruit quality (Blevins and Lukaszewski, 1998) [3]. Several tests on foliar spraying micronutrients with mulching have demonstrated a substantial response in improving fruit yield and quality and 10 to 20 times more efficient than soil application (Zaman and Achumann, 2006) [33].
This study aimed to see how foliar nutrition spraying combined with mulching affected flowering, yield, and post-harvest quality of mango fruits cv. Dashehari.

Materials and Methods
In 2021, the experiment was carried out at the Horticulture Research Center of the G.B. Pant University of Agriculture and Technology in Pantnagar, Uttarakhand. It is located at 29° North latitude, 79.3° East longitude, and is 243.84 meters above sea level. The site has a humid subtropical climate, with summer maximum temperatures ranging from 32 to 45 °C and winter minimum temperatures ranging from 0 to 9 °C. The experiment was conducted on 12 years-old trees of mango cv. Dashehari. Dashehari was planted at 5 m distance in a square system and maintained under uniform cultural practices. There were eight treatments incorporated in experiment which were T1- Mulching (September to October), T2- CaCl$_2$ + mulching (1.5%), T3- CaCl$_2$ + mulching (3.0%), T4- Ca(NO$_3$)$_2$ + mulching (2.0%), T5- Ca(NO$_3$)$_2$ + mulching (4.0%), T6- K$_2$SO$_4$ + mulching (1.0%), T7- Borax (1.0%) + mulching and T8- Control (Without mulching and nutrient). A 5 cm thick layer of paddy straw was laid on the tree basin, covering 1 m$^2$ of tree circumference.

The soil at the experiment site was sandy loam with a pH of 7.2 and 0.68 percent organic carbon, 229.30 kg ha$^{-1}$ available nitrogen, 84.67 kg ha$^{-1}$ available phosphorus, and 190.00 kg ha$^{-1}$ available potassium. The mature fruits were collected and taken to the lab for physico-chemical examination and shelf-life storage testing. Data on flowering parameters, such as panicle emergence and fruit set, were collected on alternate days from January to March 2021 to record the emergence of the first panicle on each replicated mango plant and the date of panicle emergence and fruit set. Ten fruits are used to observe fruit weight using a computerized weighing balance. Counting the number of fruits per tree was used to determine the number at harvest. Fruit yield per tree was computed by multiplying the fruit weight (kg) by the number of fruits on each tree and expressing the kilograms per tree. The biochemical quality of ten fruits was assessed using juice taken from them. TSS was calculated with a digital refractometer (ATAGO, RX 5000, Tokyo, Japan) and expressed in degrees Brix. The titratable acidity was calculated and represented as a percentage by titrating 5 mL of juice against 0.1 N NaOH. Ranganna, 2003 standard methods for determining total sugar (percent) and reducing sugar (percent) were used. The formula was used to compute the percent weight reduction for each observation:

$$PLW(\%) = \frac{Initial \ weight - Final \ Weight}{Initial \ weight} \times 100$$

The decay loss (%) was calculated on weight basis. Fruits showing rotting due to over ripening and pathogenic infection were considered decayed and weighed on the day of each observation. Weight of decayed fruits included the total weight of fruits decayed up to the date of observation. All data were subjected to Analyses of Variance (ANOVA). Significant differences among groups were determined using Duncan’s multiple range tests at p<0.05. The IBM SPSS Statistics 19 statistical programme was used for all computations and statistical analyses (IBM, NY, USA).

Results and Discussion
Effect of pre harvest treatments on flowering characteristics of mango
The data (Table 1) related to flowering parameters i.e. date of panicle emergence and fruit set in mango cv. Dashehari are influenced by different pre harvest treatments. It is evident from the data that date of panicle emergence in different treatments during the year 2021 varied from 1st February to 12th February. Mulching treatment brought earlier panicle emergence (01-05, Feb) and control showed late panicle emergence in between (06-12, Feb). Date of fruit set in Dashehari mango ranged from 17th March to 27th March. The early fruit set (17th March - 21, March) was recorded with the treatment of CaCl$_2$ (3.0%) + mulching, while late fruit set (24th March – 27th March) was recorded in control.

Table 1: Effect of mulching on date of panicle initiation and fruit set of mango cv. Dashehari

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date of panicle initiation</th>
<th>Date of fruit set</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1- Mulching</td>
<td>Feb 01- Feb 05</td>
<td>March 19 - March 23</td>
</tr>
<tr>
<td>T2- CaCl$_2$(1.5%) + mulching</td>
<td>Feb 03- Feb 09</td>
<td>March 20- March 24</td>
</tr>
<tr>
<td>T3- CaCl$_2$(3.0%) + mulching</td>
<td>Feb 04- Feb 10</td>
<td>March 17- March 21</td>
</tr>
<tr>
<td>T4- Ca(NO$_3$)$_2$(2.0%) + mulching</td>
<td>Feb 03- Feb 08</td>
<td>March 18- March 22</td>
</tr>
<tr>
<td>T5- Ca(NO$_3$)$_2$(4.0%) + mulching</td>
<td>Feb 02- Feb 07</td>
<td>March 19- March 23</td>
</tr>
<tr>
<td>T6- K$_2$SO$_4$(1.0%) + mulching</td>
<td>Feb 05- Feb 10</td>
<td>March 22- March 26</td>
</tr>
<tr>
<td>T7- Borax (1.0%) + mulching</td>
<td>Feb 04- Feb 11</td>
<td>March 20- March 23</td>
</tr>
<tr>
<td>T8- Control</td>
<td>Feb 06- Feb 12</td>
<td>March 24- March 27</td>
</tr>
</tbody>
</table>

Effect of pre harvest treatments on yield characteristics of mango
The data pertaining to fruit weight, number of fruits per tree and yield per tree are given in table 2. The data related to average fruit weight reveal that this parameter was significantly affected by various treatments. However, higher fruit weight (156.33 g) was observed with the treatment of borax (1.0%) + mulching followed by K$_2$SO$_4$(1%) + mulching treatment (146.05 g). The lowest fruit weight (119.66 g) was observed in control. The data on number of fruits per tree showed that different treatments are significantly affected. The highest number of fruits (280.53 tree$^{-1}$) was recorded with the treatment of borax (1.0%) + mulching followed by CaCl$_2$ (1.5%) + mulching (255.43 tree$^{-1}$), which were also statistically at par with each other. Lowest number of fruits (148.30 tree$^{-1}$) was observed in control. The data on fruit yield showed that different treatments are significantly affected the fruit yield (kg tree$^{-1}$). The maximum fruit yield (43.86 kg tree$^{-1}$) was recorded with the treatment of borax (1.0%) + mulching followed by CaCl$_2$ (1.5%) + mulching (35.18 kg tree$^{-1}$), which were also statistically at par with each other. Minimum fruit yield (17.75 kg tree$^{-1}$) was observed in control. Application of boron as foliar spray exhibited a positive effect because it promotes cell division, expansion, sugar
metabolism and accumulation of carbohydrates (Sourour, 2000) [32]. Due to application of boron plants exhibited better photosynthesis, accumulation of starch and auxin synthesis. The balance auxin in plant regulates the fruit drop and helps in maximum number of fruit retention. Similar results were reported in mango, papaya and guava (Sankar et al., 2013; Kavitha, 2000; Sarolia et al., 2007) [26, 16, 27].

Table 2: Effect of mulching and pre harvest foliar spray of nutrient on fruit weight, number of fruits and yield of mango cv. Dashehari

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit weight (g)</th>
<th>Number of Fruits per Tree</th>
<th>Fruit Yield (Kg tree⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁- Mulching</td>
<td>133.27cd</td>
<td>187.99d</td>
<td>25.05f</td>
</tr>
<tr>
<td>T₂- CaCl₂(1.5%) + mulching</td>
<td>137.72c</td>
<td>255.43b</td>
<td>35.18b</td>
</tr>
<tr>
<td>T₃- CaCl₂(3.0%) + mulching</td>
<td>131.88cd</td>
<td>243.02c</td>
<td>32.05c</td>
</tr>
<tr>
<td>T₄- CaNO₂(2.0%) + mulching</td>
<td>127.45e</td>
<td>237.40c</td>
<td>30.26d</td>
</tr>
<tr>
<td>T₅- CaNO₂(4.0%) + mulching</td>
<td>135.21f</td>
<td>190.33d</td>
<td>25.73f</td>
</tr>
<tr>
<td>T₆- K₂SO₄(1.0%) + mulching</td>
<td>146.05b</td>
<td>190.05d</td>
<td>27.76c</td>
</tr>
<tr>
<td>T₇- Borax (1.0%) + mulching</td>
<td>156.33a</td>
<td>280.53a</td>
<td>43.86a</td>
</tr>
<tr>
<td>T₈- Control</td>
<td>19.66f</td>
<td>148.30e</td>
<td>17.75g</td>
</tr>
</tbody>
</table>

Means within a column having same letters are statistically non-significant as per Duncan’s multiple-range test (P = 0.05); S, Significant, NS, not significant.

Effect of pre harvest treatments on fruit quality characteristics of mango

The data represented related to total soluble solids (fig. 1a), titratable acidity (fig. 1b), total sugar (fig. 2a) and reducing sugars (fig. 2b) recorded at 0th day, 5th day and 10th day during the storage period. The total soluble solids was found to be significant for different treatments during the storage period. At the end of storage (10th day) maximum total soluble solids (17.53 °Brix) was recorded with treatment of borax (1.0%) + mulching, whereas minimum (15.81 °Brix) in control. As per the data given in fig. 1b, the titratable acidity was also affected significantly by different treatment. At 10th day of storage significantly minimum acidity (0.20%) was registered with the treatment of borax (1.0%) + mulching followed by CaCl₂ (1.5%) + mulching (0.27%) whereas, maximum acidity (0.32%) was recorded in control. An increase in TSS and decrease in titratable acidity by boron application attributed to the rapid mobilization of sugars and other soluble solids from leaves to developing fruits. These findings were in agreement with the findings of Bhowmick et al., (2012) [4], Singh et al., (2012) [30], Nehete et al., (2011) [19] and Bhatt et al., (2012) [3] in mango.

The data depicted in fig. 2a reveal maximum total sugar content (15.73%) was found with treatment of borax (1.0%) + mulching while minimum in control (12.11%) at the end of storage period (10th day), it was observed that all treatments significantly increased the total sugar content as compared to control. Similarly, data depicted in fig. 2b for reducing sugars (4.78%) was found with treatment of borax (1.0%) + mulching while minimum in control (2.67%) at the end of storage period (10th day). Boron facilitates sugar transport within plants and reacts with sugar to form a sugar borate complex which reduces its consumption during metabolic processes (Stampet et al., 1999) [33]. These results were supported by results obtained earlier by Nehete et al., 2011 [19] and Bhatt et al., 2012 [3] in mango and Gaur et al., 2014 [10] in guava.

Effect of pre-harvest treatments on post-harvest quality of mango

The physiological loss in weight of Dashehari mango is significantly affected by the pre-harvest application of nutrients in comparison to control at 2nd, 5th and 10th day of storage. The data depicted in figure 3e indicate that on 10th day of storage, minimum loss in physiological weight (15.48%) was observed with the treatment of CaCl₂ (1.5%) with mulching followed by CaNO₂ (4.0%) with mulching (15.97%). However, the maximum physiological loss in weight was observed in the control (19.74%) on 10th day of storage. The decrease in weight during storage of fruits by the application of calcium may be due to its role in the maintenance of fruit firmness, reduced respiration rate and delayed senescence (Mika, 1983; Jones et al., 1970) [18, 14]. Similar results have been obtained by Siddiqui et al., (1989) [29] in Ber and Saha et al., (1998) [35] in litchi.

In the present study, a continuous decay of fruits with the advancement in storage period was observed in all the treatments. However, the control fruits showed maximum decay loss per cent (Fig. 3f) than the other treated fruits on 10 days of storage. In contrast, all the treatments were effective in lowering the decay loss significantly and minimum decay loss (15.34%) was recorded under the CaCl₂ (1.5%) with mulching at 10 days of storage. The decrease in decay loss might be due to increase in concentration of calcium of middle lamella of cell wall which provided physical strength to cell wall and improved fruit colour development and appearance (Cheour et al., 1990) [7]. This might be due to cause of mechanism by which Ca reduces decay may be related to Ca ions in cell wall (Conway et al., 1984). Calcium compounds extend the storage of many fruits by maintaining their firmness and minimizing the rate of respiration, protein break down and disease incidence (Gupta et al., 1980) [12]. This type of conformity was also reported by Ahmed et al., (2017) [1] in peache.
Fig 1: Effect of pre harvest foliar spray of nutrient on (a) TSS and (b) titratable acidity of mango cv. Dashehari
Fig 2: Effect of pre harvest foliar spray of nutrient on (c) total sugars and (d) reducing sugars of mango cv. Dashehari
Conclusion
Mulching treatment recorded earlier panicle emergence, while early fruit set was recorded with the treatment of CaCl$_2$ (3.0%) + mulching. The treatment of borax @ 1.0% + mulching is more effective for increasing the fruit weight (156.33 g), number of fruits (280.53 fruits tree$^{-1}$) yield (43.86 kg tree$^{-1}$). The increased fruit quality like TSS (17.53 °B), total sugar (15.73%) and reducing sugars (4.78%) and decreased acidity (0.20%) were registered with treatment of borax (1.0%) + mulching at end of storage period. At 10$^{th}$ days of storage minimum physiological loss in weight (15.48%) and decay loss (15.34%) of fruits were noted with the treatment of CaCl$_2$(1.5%) + mulching. Thus, the observations indicated that per-harvest application of CaCl$_2$ @ 1.5% is effective for improving the fruit shelf-life and decreasing the physiological loss in weight and decay loss whereas; the borax @1.0% with mulching proved effective for improving the fruit quality of mango cv. Dashehari.
References


