



RESEARCH ARTICLE

# Impact of various pruning intensities, bio-enhancers and biofertiliser application on vegetative growth, flowering and yield of mango (*Mangifera indica* L.) cv. Dashehari-51

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## Abstract

An experiment was conducted to assess the impact of varying intensities of pruning, bio-enhancers and bio-fertilisers on vegetative growth, flowering and yield of mango using ten treatment combinations in a randomised block design (RBD) with three replications. Significant improvements were observed across all vegetative growth, flowering and yield traits in the integrated treatments, with T<sub>9</sub>-Retention of 20 cm + 30 % fruit thinning + panchgavya (3 %) + *Azotobacter* (100 g/tree) consistently outperforming others. Specifically, in vegetative growth traits T<sub>9</sub> recorded the highest plant height (6.31 m, 6.86 m, 6.59 m), canopy height (5.83 m, 6.28 m, 6.06 m), plant spread from N-S (7.54 m, 8.56 m, 8.25 m), plant spread from E-W (8.41 m, 9.05 m, 8.73 m) and days taken to vegetative shoot emerges (45.81 days, 44.78 days, 45.30 days). In flowering and yield traits T<sub>9</sub> also recorded the highest duration of flowering (Days) (22.67 days, 22.33 days, 22.50 days), days taken for first flowering (216.33 days, 217.67 days, 217 days), days taken for 50 % flowering (228.67 days, 229.50 days, 229.09 days), number of days taken from flowering to harvesting (124.33 days, 125.67 days, 125 days), number of inflorescences per branch (10.67, 9.33, 10.00), inflorescences length (29.16 cm, 29.13 cm, 29.15 cm), inflorescences width (14.29 cm, 14.26 cm, 14.28 cm), inflorescences girth (0.67 cm, 0.66 cm, 0.67 cm), number of leaves per shoots (14.30, 14.35, 14.33), number of panicles per branch (24.67, 23.33, 24.00), number of flowers per panicle (2364.33, 1386.33, 1875.33), shoot length (25.82 cm, 25.91 cm, 25.87 cm), shoot girth (0.80 cm, 0.81 cm, 0.81 cm), fruit drop (80.64 %, 81.72 %, 81.18 %), fruit retention (19.36 %, 18.28 %, 18.82 %), fruit set (0.29 %, 0.28 %, 0.29 %), fruit yield (kg/tree) (67.17 kg/tree, 35.84 kg/tree, 51.51 kg/tree), respectively in 2023-24, 2024-25 and pooled. The study also highlighted that the integrated application of these components was superior to their individual use, suggesting a synergistic interaction that can be leveraged for sustainable and high-quality mango production.

**Keywords:** bio-enhancers; bio-fertiliser; pruning intensities; vegetative growth; yield

## Introduction

Mango (*Mangifera indica* L.) is one of the most popular and delicious fruits of the tropical regions in the world, which holds a premier position amongst all the commercial fruits in the country and is cultivated in almost all the states of India. Mangoes belong to the family Anacardiaceae, genus *Mangifera* and species *indica*, consisting of numerous species of tropical fruiting trees in the flowering plant family. The mango is indigenous to India. Mango is one of the most extensively exploited fruits for food, juice, flavour, fragrance and colour. In several cultures, its fruit and leaves are ritually used as floral decorations at weddings, public celebrations and religious ceremonies (1). The mango is one of the ancient fruits of India; it has been established in India in the pre-Christian era. Its cultivation in India is estimated to be more than 4000-6000 years old. In the Ramayana and Mahabharata, the forests and gardens of mango have been mentioned. Its blossoms are used for the worship of goddess Sarasvati and it is also called "King of fruits".

In India, mango is widely cultivated throughout the tropical and sub-tropical zones of the country except in hilly regions. The mango can grow well in all types of soil, from alluvial to lateritic, except black cotton soils, which are considered to be poor. The mango, being a deep-rooted tree, needs a soil profile of at least 2 to 2.5 m depth with good drainage capacity for the well establishment of mango orchards. The most suitable pH ranges between 5.5 and 7.0 (2). Mango can grow to an altitude of about 1400 m above sea level. The most favourable temperature for plant growth is 21 to 27 °C. In India, it is being cultivated on 2396.00 thousand hectares of land, yielding 22398.00 MT of production. Uttar Pradesh is the leading producer of mango, followed by Andhra Pradesh. (3).

Dashehari-51 is one of the most popular varieties of North India. It is a mid-season mango. Best varieties of the country; fruit size is small-medium, shape is elongated with yellow fruit colour, flesh is fibreless; good keeping quality; mainly used for table purposes; susceptible to mango malformation. Dashehari-51 regular bearing and yielding clone of Dashehari. In north India, Dashehari is an important export variety of mango for its attractive appearance,

excellent taste and pleasing flavour, which is cultivated on a commercial level and has been established through vegetative propagation to ensure multiplication of true-to-type plants. Despite this intra-varietal variability, certain varieties of mango from India and other countries have also been characterised based on morphological traits as well as genetic markers (4, 5).

Pruning is essential in managing fruit trees, helping maintain a balance between vegetative growth and fruiting. It controls tree size, improves air circulation and sunlight exposure and facilitates orchard management. While it enhances flowering and rejuvenates orchards, excessive pruning can reduce productivity in the following year. Bio-enhancers are a recent innovation in organic farming, made by fermenting cow-based products with other natural ingredients. They improve seed treatment, compost quality, soil fertility and pest control. Common farm-preparable bio-enhancers include Amritpani, Jivamrit, Vermivash and Panchgavya-all rich in beneficial microorganisms that enhance crop growth and yield. Bio-fertilisers consist of living microorganisms that mobilise nutrients like nitrogen and phosphorus. Microbes such as *Azotobacter*, *Azospirillum* and *Mycorrhiza* are widely used in horticulture to improve plant nutrition and boost productivity.

Keeping in view the above facts, the present investigation entitled "Impact of various pruning intensities, bio-enhancers and bio-fertiliser application on growth, flowering, yield and quality of mango (*Mangifera indica* L.) cv. Dashehari-51" was undertaken to comprehensively evaluate the influence of these factors on the overall performance of mango trees. The study aimed to assess the effect of different pruning intensities and the application of bio-enhancers and bio-fertilisers on growth, flowering, yield and quality attributes of mango, as well as to determine the economics of various treatment combinations for identifying the most effective and sustainable management practices to enhance productivity and fruit quality in mango cv. Dashehari-51.

The combined application of bio-enhancers, bio-fertilisers and appropriate pruning intensity will exert a synergistic effect, leading to improved vegetative growth, enhanced flowering and fruit set, superior fruit quality and higher yield in mango cv. Dashehari-51 compared to their individual applications. While individual practices such as pruning, bio-enhancer use and biofertilizer application have been studied, their integrated impact remains underexplored, especially for this commercially significant variety. Existing studies often generalise pruning methods or focus on other cultivars, lacking specific insights into the optimal combinations of pruning levels and microbial or organic inputs for Dashehari-51.

## Materials and Methods

The experiment described above was carried out at the Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during two subsequent years, 2023-24 and 2024-25. The Kanpur district is located at an elevation of 135 meters above sea level. It is situated in a subtropical zone with coordinates between 25.26° & 26.58° N

latitude and 79.31° & 80.34° E longitude. A total of ten treatment combinations were evaluated using a randomised block design (RBD) with three replications, involving pruning intensities, bio-enhancers and biofertilizer application. The pruning was done in the month of June. The treatments are T<sub>0</sub>-Control (no pruning only water spray), T<sub>1</sub>-Retention of 10 cm + 10 % Fruit Thinning + Amritpani (25 %) + *Azotobacter* (100 g/tree), T<sub>2</sub>-Retention of 10 cm + 10 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree), T<sub>3</sub>-Retention of 10 cm +10 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), T<sub>4</sub>-Retention of 15 cm + 20 % Fruit Thinning + Amritpani (25 %) + *Azotobacter* (100 g/tree), T<sub>5</sub>-Retention of 15 cm + 20 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree), T<sub>6</sub>-Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), T<sub>7</sub>-Retention of 20 cm + 30 % Fruit Thinning + Amritpani (25 %) + *Azotobacter* (100 g/tree), T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree), T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree).

### Application schedule

The foliar sprays of bio-enhancers and bio-fertilisers were done before and after flowering in 2023 and 2024 (Table 1). For the foliar application of spray on the mango plant, such as to adequately drench the entire foliage, 10 L of solution was used for the spraying, which is done by using a pneumatic foot sprayer fitted with a nozzle in the afternoon from 4.00 pm to 6.00 pm. For spraying on top of the plant, a high-legged stool was used to ensure that all sides of the plant were completely drenched. To avoid the spread of surplus spray under the plants, the polythene sheets were spread on the soil so that spray drops would not reach the soil.

### Observations recorded

The following traits were recorded during the study:

#### Growth attributes

The plant height (m) was measured from the ground level to the tip of the top shoot using a bamboo stick as a measuring tool. The canopy height (m) was measured from the point of primary branching to the tip of the terminal shoot. Plant spread was measured in both the North-South (N-S) and East-West (E-W) directions with the help of a measuring tape to determine the overall canopy spread. The number of days taken for vegetative shoot emergence was recorded from the date of pruning to the date of new shoot emergence.

#### Flowering attributes

The flowering and associated morphological parameters of mango plants were recorded through regular observations on the experimental trees. The duration of flowering (days) was determined as the period from the first visible flower appearance to the last flower senescence on the plant. The days taken for first flowering, 50 % flowering and from flowering to harvesting were measured from the date after pruning. The number of inflorescences per branch was recorded from five selected and tagged branches and the mean value was calculated. Inflorescence length (cm), width (cm), girth (cm), shoot length (cm) and shoot girth (cm) were measured using a

**Table 1.** Method of preparation of a solution of nutrients

| S. No. | Materials used     | Concentrations | Weight of bio-enhancer/bio-fertiliser (per litre of water) |
|--------|--------------------|----------------|------------------------------------------------------------|
| 1.     | Panchgavya         | 3.0 %          | 30 mL                                                      |
| 2.     | Jivamrit           | 25.0 %         | 250 mL                                                     |
| 3.     | Amritpani          | 25.0 %         | 250 mL                                                     |
| 4.     | <i>Azotobacter</i> | 100 g/tree     | 100 g                                                      |

measuring scale. The number of leaves per shoot, panicles per branch and flowers per panicle were also recorded from marked and tagged branches and panicles. For this, five branches were selected and tagged for observation; the number of leaves and panicles per branch was counted and their mean values were taken as final records. Similarly, ten panicles were tagged across five branches and the number of flowers per panicle was counted, with the average value used for final observation.

#### Yield attributes

**Fruit drop:** The recording of fruit drop percentage in mango, on each treated plant, the four bearing branches in four directions were tagged and the total number of fruit buds/fruit leaves was counted. The data related to the total number of fruit buds/fruit leaves dropped on each branch were counted at 15<sup>th</sup> day's intervals. The average of the total number of fruits that were dropped from each branch was calculated as a percentage of fruit drop by using the following formula.

$$\text{Fruit drop (\%)} = \frac{\text{No. of fruitlets at initial stage} - \text{No. of fruit retention at harvest}}{\text{No. of fruitlets at the initial stage}} \times 100 \quad (\text{Eqn. 1})$$

**Fruit retention (%):** To assess the percentage of fruit retention on mango plants, the number of initial fruits set and remaining fruits after fruit shedding in each bio-fertiliser and bio-enhancer treatment at the time of harvesting was noted. Fruit retention per cent was calculated by using the following formula.

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruits retained per Determinate shoot till maturity}}{\text{Total number of fruits set per Determinate shoot}} \times 100 \quad (\text{Eqn. 2})$$

**Fruit set:** At full bloom, several flowers per selected panicle were counted manually from 5–10 randomly tagged panicles per plant. After fruit set, the number of developing fruits on the same panicles was counted.

The fruit set percentage was calculated using the formula:

$$\text{Fruit set (\%)} = \frac{\text{Number of flowers}}{\text{Number of fruits set}} \times 100 \quad (\text{Eqn. 3})$$

**Fruit yield:** The weight of all fruits recorded the total fruit yield per plant after harvesting the fruits. The average fruit yield (kg per plant) was recorded per treatment.

#### Statistical analysis

The data obtained were statistically analysed using RBD. The significance of treatment effects was tested through an F-test and critical differences (C.D.) at 5 % probability levels were calculated for comparison among treatment means. (6). Multivariate relationships among treatments and traits were evaluated using principal component analysis (PCA) performed with SPSS software (version 25.0) (7).

## Results and Discussion

#### Growth attributes

The effect of pruning intensities, bio-enhancers and bio-fertilisers significantly influenced plant height (m), canopy height (m), plant

spread from N-S (m), plant spread from E-W (m) and days taken to vegetative shoot emergence over both seasons. The application of Retention of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree) consistently outperformed others across all traits.

#### Plant height

The perusal of data related to plant height clearly revealed that the maximum plant height (6.31 m, 6.86 m and 6.59 m) was recorded in mango plants which were treated with the application of retention of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of Retention of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 6.20 m, 6.71 m, 6.46 m, respectively (Table 2). The minimum plant height (5.30 m, 5.71 m, 5.51 m) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilisers provides balanced nourishment to the plants. The pruning is an unavoidable necessity of virtually all arboreal fruit crops and is adopted to maintain proper physiological balance between growth and fruiting. Pruning also prevents the plant from getting too large and annual pruning regulates the flower management programme and reshapes the intermediate size of plants. These findings are consistent with similar studies carried out in mango, ber, pomegranate, guava, dragon fruit and strawberry (8–14).

#### Canopy height

The perusal of data related to canopy height (Table 2) clearly revealed that the maximum canopy height (5.83 m, 6.28 m, 6.06 m) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 5.48 m, 5.92 m, 5.48 m, respectively. The minimum canopy height (4.59 m, 4.97 m, 4.75 m) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively, in 2023-24, 2024-25 and pooled. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilisers provides balanced nourishment to the plants. This may be because the foliar application of Panchgavya, when applied topically consistently, results in larger leaves and a denser canopy. These findings are consistent with similar studies carried out in mango and guava (15–18).

#### Plant spread from N-S

The perusal of data related to plant spread (Table 2) clearly revealed that the maximum plant spread (7.54 m, 8.56 m, 8.25 m) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 7.85 m, 8.42 m, 8.14 m, respectively. The minimum plant spread (6.91 m, 7.38 m, 7.15 m) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023–24,

**Table 2.** Impact of various pruning intensities, bio-enhancers and bio-fertilizer application on vegetative growth of mango (*Mangifera indica* L.)

| Treatment notation | Plant height (m) |         |        | Canopy height (m) |         |        | Plant spread from N-S (m) |         |        | Plant spread from E-W (m) |         |        | Days taken to vegetative shoot emerges |         |        |
|--------------------|------------------|---------|--------|-------------------|---------|--------|---------------------------|---------|--------|---------------------------|---------|--------|----------------------------------------|---------|--------|
|                    | 2023-24          | 2024-25 | pooled | 2023-24           | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                                | 2024-25 | pooled |
| T <sub>0</sub>     | 5.30             | 5.71    | 5.51   | 4.59              | 4.97    | 4.78   | 6.91                      | 7.38    | 7.15   | 7.21                      | 7.82    | 7.52   | 55.33                                  | 54.67   | 55.00  |
| T <sub>1</sub>     | 5.41             | 5.84    | 5.63   | 4.71              | 5.08    | 4.90   | 7.14                      | 7.70    | 7.42   | 7.84                      | 8.32    | 8.08   | 54.91                                  | 53.92   | 54.42  |
| T <sub>2</sub>     | 5.52             | 5.96    | 5.74   | 4.82              | 5.16    | 4.99   | 7.29                      | 7.83    | 7.56   | 7.91                      | 8.42    | 8.17   | 54.67                                  | 53.61   | 54.14  |
| T <sub>3</sub>     | 5.84             | 6.30    | 6.07   | 5.10              | 5.54    | 5.32   | 7.51                      | 8.04    | 7.78   | 8.10                      | 8.58    | 8.34   | 52.21                                  | 51.12   | 51.67  |
| T <sub>4</sub>     | 5.61             | 6.12    | 5.87   | 4.98              | 5.36    | 5.17   | 7.40                      | 7.96    | 7.68   | 8.02                      | 8.54    | 8.28   | 53.67                                  | 52.33   | 53.00  |
| T <sub>5</sub>     | 5.91             | 6.34    | 6.13   | 5.21              | 5.72    | 5.47   | 7.68                      | 8.10    | 7.89   | 8.18                      | 8.61    | 8.40   | 50.33                                  | 49.67   | 50.00  |
| T <sub>6</sub>     | 6.09             | 6.60    | 6.35   | 5.40              | 5.89    | 5.65   | 7.78                      | 8.31    | 8.05   | 8.31                      | 8.81    | 8.56   | 47.28                                  | 46.23   | 46.76  |
| T <sub>7</sub>     | 6.01             | 6.49    | 6.25   | 5.30              | 5.84    | 5.57   | 7.71                      | 8.26    | 7.99   | 8.26                      | 8.74    | 8.50   | 49.33                                  | 48.67   | 49.00  |
| T <sub>8</sub>     | 6.20             | 6.71    | 6.46   | 5.48              | 5.92    | 5.70   | 7.85                      | 8.42    | 8.14   | 8.36                      | 8.90    | 8.63   | 46.67                                  | 45.43   | 46.05  |
| T <sub>9</sub>     | 6.31             | 6.86    | 6.59   | 5.83              | 6.28    | 6.06   | 7.94                      | 8.56    | 8.25   | 8.41                      | 9.05    | 8.73   | 45.81                                  | 44.78   | 45.30  |
| F test             | S                | S       | S      | S                 | S       | S      | S                         | S       | S      | S                         | S       | S      | S                                      | S       | S      |
| S.E.(m)±           | 0.076            | 0.099   | 0.071  | 0.076             | 0.093   | 0.071  | 0.100                     | 0.077   | 0.061  | 0.093                     | 0.146   | 0.096  | 0.679                                  | 0.717   | 0.562  |
| C.D.(P=0.05)       | 0.227            | 0.298   | 0.211  | 0.227             | 0.280   | 0.214  | 0.298                     | 0.231   | 0.184  | 0.278                     | 0.436   | 0.289  | 2.032                                  | 2.148   | 1.682  |

S- Significant, T<sub>0</sub>- Control (no pruning only water spray), T<sub>1</sub>- Retention of 10 cm + 10 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>2</sub>-Retention of 10 cm + 10 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>3</sub> - Retention of 10 cm +10 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>4</sub>- Retention of 15 cm + 20 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>5</sub>- Retention of 15 cm + 20 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>6</sub>- Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>7</sub>- Retention of 20 cm + 30 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>8</sub>- Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>9</sub>- Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree).

2024-25 and pooled. Pruning also prevents the plant from getting too large and annual pruning regulates the flower management programme and reshapes the intermediate size of plants. Bio-enhancers, i.e., Amritpani, Panchgavya and Jivaamrit, may act as an alternative supply of nutrients in bio-available forms, as well as organic acids, enzymes and beneficial micro-flora stimuli toward soil microbial activity to enhance the interaction of roots with the rhizosphere. Together, these promote improved nutrient-use efficiency, more extensive root proliferation and enhanced photosynthetic activity, which manifests as wide canopy development and increased plant spread. These findings are consistent with similar studies carried out in pomegranate, dragon fruit and mango (11, 13, 15, 17, 19).

#### Plant spread from E-W

The perusal of data related to plant spread (Table 2) clearly revealed that the maximum plant spread (8.41 m, 9.05 m, 8.73 m) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 8.36 m, 8.90 m, 8.63 m, respectively. The minimum plant spread (7.21 m, 7.82 m, 7.52 m) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Pruning also prevents the plant from getting too large and annual pruning regulates the flower management programme and reshapes the intermediate size of plants. Bio-enhancers, i.e., Amritpani, Panchgavya and Jivaamrit, may act as an alternative supply of nutrients in bio-available forms, as well as organic acids, enzymes and beneficial micro-flora stimuli toward soil microbial activity to enhance the interaction of roots with the rhizosphere. Together, these promote improved nutrient-use efficiency, more extensive root proliferation and enhanced photosynthetic activity, which manifests as wide canopy development and increased plant spread. These findings are consistent with similar studies carried out in pomegranate, dragon fruit and mango (11, 13, 15, 17, 19).

#### Days taken to vegetative shoot emerges

The perusal of data related to days taken to vegetative shoot emerges (Table 2) clearly revealed that the minimum days taken to vegetative shoot emerges (45.81 days, 44.78 days, 45.30 days) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 46.67 days, 45.43 days, 46.05 days, respectively. The maximum days taken to vegetative shoot emerges (55.33 days, 54.67 days, 55.00 days) were recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in mango, citrus and guava (19–24).

#### Flowering attributes

The effect of pruning intensities, bio-enhancers and bio-fertilizers significantly influenced duration of flowering (Days), days taken for first flowering, days taken for 50 % flowering, number of days taken from flowering to harvesting (days), number of inflorescences per branch, inflorescences length (cm),

inflorescences width (cm), inflorescences girth (cm), number of leaves per shoots, number of panicles per branch, number of flowers per panicle, shoot length (cm), shoot girth (cm) over both seasons. The application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree) consistently outperformed others across all traits.

#### Duration of flowering

The perusal of data related to duration of flowering (Table 3) clearly revealed that the maximum duration of flowering (22.67 days, 22.33 days, 22.50 days) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 21.33 days, 20.67 days, 21.00 days, respectively. The minimum duration of flowering (16.33 days, 16.00 days, 16.17 days) was recorded with the T<sub>0</sub>-Control (no pruning only water spray), respectively in 2023-24, 2024-25 and pooled. Pruning, besides better light penetration, forces the early initiation of new shoots, causing them to reach maturity, which has sufficient time for the accumulation of photosynthates that are promotive for flowering. These findings are consistent with similar studies carried out in ber, guava and mango (10, 22, 24–26).

#### Days taken for first flowering

The perusal of data related to days taken for first flowering (Table 3) clearly revealed that the minimum days taken for first flowering (216.33 days, 217.67 days, 217.00 days) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 217.67 days, 218.33 days, 218.00 days, respectively. The maximum days taken for first flowering (226.67 days, 227.33 days, 227.00 days) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. This may be attributable to the combined use of bio-enhancers (Panchgavya), which include a beneficial microbial population and bio-fertilisers (*Azotobacter*), which may have facilitated the plant's ability to flower. These findings are consistent with similar studies carried out in dragon fruit, strawberry, mango and papaya (13, 27–29).

#### Days taken for 50 % flowering

The perusal of data related to days taken for 50 % flowering (Table 3) clearly revealed that the minimum days taken for 50 % flowering (228.67 days, 229.50 days, 229.09 days) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 229.50 days, 230.00 days, 229.75 days, respectively. The maximum days taken for 50 % flowering (239.67 days, 240.33 days, 240.00 days) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in dragon fruit, strawberry and mango (13, 27, 28).

**Table 3.** Impact of various pruning intensities, bio-enhancers and bio-fertiliser application on flowering of mango (*Mangifera indica* L.)

| Treatments      | Notation | Duration of flowering (Days) |         | Days taken for first flowering |        | Days taken for 50 % flowering |        | Number of days taken from flowering to harvesting (days) |        |         |        | Number of inflorescences per branch |        |         |        | Number of panicles per branch |        |         |        | Number of flowers per panicle |         |         |        |
|-----------------|----------|------------------------------|---------|--------------------------------|--------|-------------------------------|--------|----------------------------------------------------------|--------|---------|--------|-------------------------------------|--------|---------|--------|-------------------------------|--------|---------|--------|-------------------------------|---------|---------|--------|
|                 |          | 2023-24                      | 2024-25 | 2023-24                        |        | 2024-25                       |        | 2023-24                                                  |        | 2024-25 |        | 2023-24                             |        | 2024-25 |        | 2023-24                       |        | 2024-25 |        | 2023-24                       |         | 2024-25 |        |
|                 |          |                              |         | pooled                         | pooled | pooled                        | pooled | pooled                                                   | pooled | pooled  | pooled | pooled                              | pooled | pooled  | pooled | pooled                        | pooled | pooled  | pooled | pooled                        | pooled  | pooled  | pooled |
| T <sub>0</sub>  |          | 16.33                        | 16.00   | 16.17                          | 226.67 | 227.33                        | 227.00 | 239.67                                                   | 240.33 | 240.00  | 135.67 | 136.67                              | 136.17 | 4.67    | 3.33   | 4.00                          | 10.33  | 9.67    | 10.00  | 1876.66                       | 784.67  | 1330.67 |        |
| T <sub>1</sub>  |          | 17.33                        | 16.67   | 17.00                          | 225.33 | 226.50                        | 225.92 | 238.50                                                   | 239.33 | 238.92  | 134.33 | 135.67                              | 135.00 | 5.33    | 4.00   | 4.67                          | 13.67  | 13.33   | 13.50  | 1898.33                       | 850.66  | 1374.50 |        |
| T <sub>2</sub>  |          | 18.33                        | 17.33   | 17.83                          | 224.33 | 225.00                        | 224.67 | 237.00                                                   | 238.33 | 237.67  | 132.67 | 133.67                              | 133.17 | 5.67    | 4.67   | 5.17                          | 14.67  | 14.33   | 14.50  | 1906.67                       | 891.67  | 1399.17 |        |
| T <sub>3</sub>  |          | 19.33                        | 18.67   | 19.00                          | 222.50 | 223.00                        | 222.75 | 234.50                                                   | 235.33 | 234.92  | 130.33 | 131.67                              | 131.00 | 6.67    | 5.33   | 6.00                          | 16.33  | 16.00   | 16.17  | 1951.33                       | 941.67  | 1446.50 |        |
| T <sub>4</sub>  |          | 18.67                        | 18.33   | 18.50                          | 223.50 | 224.33                        | 223.92 | 236.67                                                   | 237.00 | 236.84  | 131.67 | 132.33                              | 132.00 | 6.33    | 5.00   | 5.67                          | 15.67  | 15.33   | 15.50  | 1931.67                       | 910.50  | 1421.09 |        |
| T <sub>5</sub>  |          | 19.67                        | 19.33   | 19.50                          | 221.67 | 222.33                        | 222.00 | 233.33                                                   | 234.00 | 233.67  | 129.67 | 130.67                              | 130.17 | 7.33    | 5.67   | 6.50                          | 18.33  | 17.67   | 18.00  | 1974.33                       | 1005.50 | 1489.92 |        |
| T <sub>6</sub>  |          | 20.67                        | 20.33   | 20.50                          | 218.33 | 219.67                        | 219.00 | 230.00                                                   | 231.33 | 230.67  | 126.00 | 127.50                              | 126.75 | 8.67    | 7.33   | 8.00                          | 21.67  | 20.33   | 21.00  | 2120.00                       | 1126.33 | 1623.17 |        |
| T <sub>7</sub>  |          | 20.33                        | 19.67   | 20.00                          | 220.50 | 221.50                        | 221.00 | 232.00                                                   | 233.33 | 232.67  | 128.67 | 129.33                              | 129.00 | 7.67    | 6.33   | 7.00                          | 19.33  | 18.67   | 19.00  | 2011.33                       | 1050.91 | 1531.12 |        |
| T <sub>8</sub>  |          | 21.33                        | 20.67   | 21.00                          | 217.67 | 218.33                        | 218.00 | 229.50                                                   | 230.00 | 229.75  | 125.67 | 126.33                              | 126.00 | 9.33    | 8.67   | 9.00                          | 23.33  | 22.67   | 23.00  | 2284.67                       | 1281.67 | 1783.17 |        |
| T <sub>9</sub>  |          | 22.67                        | 22.33   | 22.50                          | 216.33 | 217.67                        | 217.00 | 228.67                                                   | 229.50 | 229.09  | 124.33 | 125.67                              | 125.00 | 10.67   | 9.33   | 10.00                         | 24.67  | 23.33   | 24.00  | 2364.33                       | 1386.33 | 1875.33 |        |
| t test          |          | S                            | S       | S                              | S      | S                             | S      | S                                                        | S      | S       | S      | S                                   | S      | S       | S      | S                             | S      | S       | S      | S                             | S       | S       |        |
| S.E.(m)±        |          | 0.340                        | 0.320   | 0.252                          | 2.41   | 3.45                          | 1.93   | 4.10                                                     | 2.51   | 2.66    | 1.75   | 2.05                                | 1.60   | 0.10    | 0.08   | 0.06                          | 0.26   | 0.30    | 0.16   | 29.85                         | 17.33   | 11.73   |        |
| C.D.<br>P=0.05) |          | 1.019                        | 0.957   | 0.754                          | 7.16   | 10.27                         | 5.78   | 12.19                                                    | 7.46   | 7.92    | 5.24   | 6.13                                | 4.79   | 0.32    | 0.26   | 0.18                          | 0.79   | 0.91    | 0.47   | 89.40                         | 51.88   | 35.11   |        |

S- Significant, T<sub>0</sub>- Control (no pruning only water spray), T<sub>1</sub>- Retention of 10 cm + 10 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>2</sub>-Retention of 10 cm + 10 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>3</sub> - Retention of 10 cm +10 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>4</sub>- Retention of 15 cm + 20 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), Retention of 15 cm + 20 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>5</sub>- Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>6</sub>- Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>7</sub>- Retention of 20 cm + 30 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>8</sub>- Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>9</sub>- Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree).

### Number of days taken from flowering to harvesting

The perusal of data related to number of days taken from flowering to harvesting (Table 3) clearly revealed that the minimum number of days taken from flowering to harvesting (124.33 days, 125.67 days, 125.00 days) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 125.67 days, 126.33 days, 126.00 days, respectively. The maximum number of days taken from flowering to harvesting (135.67 days, 136.67 days, 136.17 days) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in dragon fruit, strawberry and mango (13, 27, 28).

### Number of inflorescences per branch

The perusal of data related to number of inflorescences per branch (Table 3) clearly revealed that the maximum number of inflorescences per branch (10.67, 9.33, 10.00) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 9.33, 8.67, 9.00, respectively. The minimum number of inflorescences per branch (4.67, 3.33, 4.00) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. The integration of panchgavya and bio-fertilisers may be responsible for the increase in inflorescences per branch because panchgavya promotes crop growth and vigour while also fostering resistance to pests and diseases. These findings are consistent with similar studies carried out in mango (30–32).

### Inflorescences length

The perusal of data related to inflorescences length (Table 4) clearly revealed that the maximum inflorescences length (29.16 cm, 29.13 cm, 29.15 cm) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 29.04 cm, 29.01 cm, 29.03 cm, respectively. The minimum inflorescence length (25.04 cm, 25.01 cm, 25.03 cm) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilisers provides balanced nourishment to the plants when *Azotobacter* are present. These findings are consistent with similar studies carried out in mango and strawberry (24, 32–34).

### Inflorescences width

The perusal of data related to inflorescences width (Table 4) clearly revealed that the maximum inflorescences width (14.29 cm, 14.26 cm, 14.28 cm) was recorded in mango plants which were treated

with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 14.10 cm, 14.06 cm, 14.08 cm). The minimum inflorescence width (11.31 cm, 11.26 cm, 11.29 cm) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in mango (24, 32, 33).

### Inflorescences girth

The perusal of data related to inflorescences girth (Table 4) clearly revealed that the maximum inflorescences girth (0.67 cm, 0.66 cm, 0.67 cm) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically at par with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 0.65 cm, 0.63 cm, 0.64 cm, respectively. The minimum inflorescence girth (0.50 cm, 0.49 cm, 0.50 cm) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively, in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in mango (24, 32, 33).

### Number of leaves per shoots

The perusal of data related to number of leaves per shoots (Table 4) clearly revealed that the maximum number of leaves per shoots (14.30, 14.35, 14.33) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 14.11, 14.16, 14.14, respectively. The minimum number of leaves per shoot (11.66, 11.74, 11.70) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in citrus, strawberry, mango and guava (12, 21, 23, 27, 30, 34–36).

### Number of panicles per branch

The perusal of data related to the number of panicles per branch (Table 3) clearly revealed that the maximum number of panicles per branch (24.67, 23.33, 24.00) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree). which was followed by the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the values of 23.33, 22.67, 23.00, respectively. The minimum number of panicles per branch (10.33, 9.67, 10.00) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Pruning, besides better light penetration, forces the early initiation of new shoots, causing them to reach maturity, which has sufficient time for the accumulation of photosynthates that are promotive for flowering. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilisers provides balanced nourishment to the plants when *Azotobacter* are present. These findings are consistent with similar studies carried out in strawberry, banana and mango (8, 34, 36).

**Table 4.** Impact of various pruning intensities, bio-enhancers and bio-fertilizer application on flowering of mango (*Mangifera indica* L.)

| Treatment<br>Notation | Inflorescences length (cm) |         |        | Inflorescences width (cm) |         |        | Inflorescences girth (cm) |         |        | Number of leaves per shoots |         |        | shoot length (cm) |         |        | Shoot girth (cm) |         |        |
|-----------------------|----------------------------|---------|--------|---------------------------|---------|--------|---------------------------|---------|--------|-----------------------------|---------|--------|-------------------|---------|--------|------------------|---------|--------|
|                       | 2023-24                    | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                     | 2024-25 | pooled | 2023-24           | 2024-25 | pooled | 2023-24          | 2024-25 | pooled |
|                       | 2023-24                    | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                   | 2024-25 | pooled | 2023-24                     | 2024-25 | pooled | 2023-24           | 2024-25 | pooled | 2023-24          | 2024-25 | pooled |
| T <sub>0</sub>        | 25.04                      | 25.01   | 25.03  | 11.31                     | 11.26   | 11.29  | 0.50                      | 0.49    | 0.50   | 11.66                       | 11.74   | 11.70  | 19.64             | 19.78   | 19.71  | 0.58             | 0.60    | 0.59   |
| T <sub>1</sub>        | 25.91                      | 25.85   | 25.88  | 12.21                     | 12.19   | 12.20  | 0.53                      | 0.51    | 0.52   | 12.05                       | 12.10   | 12.08  | 20.39             | 20.48   | 20.44  | 0.61             | 0.63    | 0.62   |
| T <sub>2</sub>        | 26.33                      | 26.29   | 26.31  | 12.46                     | 12.41   | 12.44  | 0.54                      | 0.52    | 0.53   | 12.50                       | 12.56   | 12.53  | 21.42             | 21.52   | 21.47  | 0.63             | 0.65    | 0.64   |
| T <sub>3</sub>        | 27.31                      | 27.26   | 27.29  | 13.11                     | 13.09   | 13.10  | 0.58                      | 0.56    | 0.57   | 13.12                       | 13.16   | 13.14  | 22.70             | 22.81   | 22.76  | 0.69             | 0.70    | 0.70   |
| T <sub>4</sub>        | 26.84                      | 26.75   | 26.80  | 12.82                     | 12.78   | 12.80  | 0.55                      | 0.54    | 0.55   | 12.90                       | 12.93   | 12.92  | 22.31             | 22.39   | 22.35  | 0.67             | 0.68    | 0.68   |
| T <sub>5</sub>        | 27.91                      | 27.84   | 27.88  | 13.41                     | 13.39   | 13.40  | 0.60                      | 0.59    | 0.60   | 13.40                       | 13.45   | 13.43  | 23.02             | 23.09   | 23.06  | 0.70             | 0.72    | 0.71   |
| T <sub>6</sub>        | 28.84                      | 28.76   | 28.80  | 13.91                     | 13.88   | 13.90  | 0.63                      | 0.61    | 0.62   | 13.91                       | 13.95   | 13.93  | 24.61             | 24.74   | 24.68  | 0.74             | 0.76    | 0.75   |
| T <sub>7</sub>        | 28.41                      | 28.36   | 28.39  | 13.74                     | 13.72   | 13.73  | 0.61                      | 0.60    | 0.61   | 13.70                       | 13.75   | 13.73  | 23.48             | 23.61   | 23.55  | 0.73             | 0.74    | 0.74   |
| T <sub>8</sub>        | 29.04                      | 29.01   | 29.03  | 14.10                     | 14.06   | 14.08  | 0.65                      | 0.63    | 0.64   | 14.11                       | 14.16   | 14.14  | 25.04             | 25.10   | 25.07  | 0.78             | 0.79    | 0.79   |
| T <sub>9</sub>        | 29.16                      | 29.13   | 29.15  | 14.29                     | 14.26   | 14.28  | 0.67                      | 0.66    | 0.67   | 14.30                       | 14.35   | 14.33  | 25.82             | 25.91   | 25.87  | 0.80             | 0.81    | 0.81   |
| F test                | S                          | S       | S      | S                         | S       | S      | S                         | S       | S      | S                           | S       | S      | S                 | S       | S      | S                | S       | S      |
| S.E.(m)±              | 0.40                       | 0.39    | 0.31   | 0.21                      | 0.19    | 0.15   | 0.008                     | 0.010   | 0.008  | 0.21                        | 0.11    | 0.10   | 0.30              | 0.33    | 0.24   | 0.012            | 0.012   | 0.010  |
| C.D. (P=0.05)         | 1.21                       | 1.19    | 0.92   | 0.63                      | 0.57    | 0.47   | 0.025                     | 0.030   | 0.023  | 0.64                        | 0.35    | 0.32   | 0.92              | 0.99    | 0.74   | 0.037            | 0.036   | 0.031  |

S- Significant, T<sub>0</sub>- Control (no pruning only water spray), T<sub>1</sub>- Retention of 10 cm + 10 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>2</sub>- Retention of 10 cm + 10 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>3</sub> - Retention of 10 cm +10 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>4</sub>- Retention of 15 cm + 20 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>5</sub>- Retention of 15 cm + 20 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>6</sub>- Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>7</sub>- Retention of 20 cm + 30 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>8</sub>- Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>9</sub>- Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree).

### Number of flowers per panicle

The perusal of data related to number of flowers per panicle (Table 3) clearly revealed that the maximum number of flowers per panicle (2364.33, 1386.33, 1875.33) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 2284.67, 1281.67, 1783.17, respectively. The minimum number of flowers per panicle (1876.66, 784.67, 1330.67) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. Pruning, besides better light penetration, forces the early initiation of new shoots, causing them to reach maturity, which has sufficient time for the accumulation of photosynthates that are promotive for flowering. These findings are consistent with similar studies carried out in mango, strawberry and papaya (33, 34, 37–39).

### Shoot length

The perusal of data related to shoot length (Table 4) clearly revealed that the maximum shoot length (25.82 cm, 25.91 cm, 25.87 cm) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 25.04 cm, 25.10 cm, 25.07 cm, respectively. The minimum shoot length (19.64 cm, 19.78 cm, 19.78 cm) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. The pruning is an unavoidable necessity of virtually all arboreal fruit crops and is adopted to maintain proper physiological balance between growth and fruiting. Additionally, it was claimed that the panchgavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilisers provides balanced nourishment to the plants when *Azotobacter* are present. These findings are consistent with similar studies carried out in mango, citrus and strawberry (19, 21, 23, 25, 27).

### Shoot girth

The perusal of data related to shoot girth (Table 4) clearly revealed that the maximum shoot girth (0.80 cm, 0.81 cm, 0.81 cm) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was statistically followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 0.78 cm, 0.79 cm, 0.79 cm, respectively. The minimum shoot girth (0.58 cm, 0.60 cm, 0.59 cm) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. The pruning is an unavoidable necessity of virtually all arboreal fruit crops and is adopted to maintain proper physiological balance between growth and fruiting. The use of bio-fertilisers significantly enhanced the soil's microbial population, thereby improving the soil's ability to support plant growth and productivity. These findings are consistent with similar studies carried out in mango, citrus and strawberry (19, 21, 23, 25, 27, 28).

### Yield attributes

The effect of pruning intensities, bio-enhancers and bio-fertilisers significantly influenced fruit drop (%), fruit retention (%), fruit set (%)

and fruit yield (kg/tree) over both seasons. The application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree) consistently outperformed others across all traits.

### Fruit drop

The perusal of data related to fruit drop (Table 5) clearly revealed that the minimum fruit drop (80.64 %, 81.72 %, 81.18 %) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 81.78 %, 82.89 %, 82.34 %, respectively. The maximum fruit drop (92.43 %, 93.89 %, 93.16 %) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. In addition, these results suggest that the integration of Panchgavya and biofertilizers contributed to increased inflorescence per branch by enhancing crop growth, vigour and resistance to pests and diseases, boosting growth and production. Biofertilizers such as *Azotobacter* and organic manures like FYM provide balanced nutrition by biologically fixing nitrogen, solubilising phosphate and promoting growth with essential elements such as vitamins and hormones. These findings are consistent with similar studies carried out in strawberry and mango (34, 40–42).

### Fruit retention

The perusal of data related to fruit retention (Table 5) clearly revealed that the maximum fruit retention (19.36 %, 18.28 %, 18.82 %) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 18.22 %, 17.11 %, 17.67 %, respectively. The minimum fruit retention (7.57 %, 6.11 %, 6.84 %) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. These findings are consistent with similar studies carried out in strawberry, mango and guava (24, 42–44).

### Fruit set

The perusal of data related to fruit set (Table 5) clearly revealed that the maximum fruit set (0.29 %, 0.28 %, 0.29 %) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 0.26 %, 0.25 %, 0.26 %, respectively. The minimum fruit set (0.11 %, 0.10 %, 0.11 %) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. This is attributed to the fact that panchgavya contains various micro-organisms, especially bacteria, along with a high concentration of various plant hormones, especially auxins, gibberellins and cytokinins. which improves the fruit plant growth. In addition to this, *Azotobacter* affects plant growth directly by changing the microflora of the rhizosphere and by fixing the atmospheric nitrogen. *Azotobacter* intensifies the activity of rhizosphere microflora involved in ammonification, nitrification, cellulose decomposition and phosphate mineralisation. These findings are consistent with similar studies carried out in strawberry, mango and papaya (27, 39–41).

**Table 5.** Impact of various pruning intensities, bio-enhancers and bio-fertiliser application on the yield of mango (*Mangifera indica* L.)

| Code           | Fruit drop (%) |         |        | Fruit retention (%) |         |        | Fruit set (%) |         |        | Fruit yield (kg/tree) |         |        |
|----------------|----------------|---------|--------|---------------------|---------|--------|---------------|---------|--------|-----------------------|---------|--------|
|                | 2023-24        | 2024-25 | pooled | 2023-24             | 2024-25 | pooled | 2023-24       | 2024-25 | pooled | 2023-24               | 2024-25 | pooled |
| T <sub>0</sub> | 92.43          | 93.89   | 93.16  | 7.57                | 6.11    | 6.84   | 0.11          | 0.10    | 0.11   | 35.94                 | 12.71   | 24.33  |
| T <sub>1</sub> | 91.72          | 92.04   | 91.88  | 8.28                | 7.96    | 8.12   | 0.14          | 0.12    | 0.13   | 40.70                 | 13.89   | 27.30  |
| T <sub>2</sub> | 90.62          | 91.78   | 91.20  | 9.38                | 8.22    | 8.80   | 0.15          | 0.14    | 0.15   | 42.83                 | 14.50   | 28.67  |
| T <sub>3</sub> | 86.67          | 87.98   | 87.33  | 13.33               | 12.02   | 12.68  | 0.18          | 0.17    | 0.18   | 48.92                 | 18.28   | 33.60  |
| T <sub>4</sub> | 88.93          | 90.36   | 89.65  | 11.07               | 9.64    | 10.36  | 0.17          | 0.16    | 0.17   | 45.43                 | 16.60   | 31.02  |
| T <sub>5</sub> | 85.62          | 86.77   | 86.20  | 14.38               | 13.23   | 13.81  | 0.20          | 0.19    | 0.20   | 51.22                 | 22.85   | 37.04  |
| T <sub>6</sub> | 82.98          | 83.89   | 83.44  | 17.02               | 16.11   | 16.57  | 0.24          | 0.23    | 0.24   | 58.21                 | 27.85   | 43.03  |
| T <sub>7</sub> | 83.49          | 84.74   | 84.12  | 16.51               | 15.26   | 15.89  | 0.21          | 0.20    | 0.21   | 55.89                 | 25.79   | 40.84  |
| T <sub>8</sub> | 81.78          | 82.89   | 82.34  | 18.22               | 17.11   | 17.67  | 0.26          | 0.25    | 0.26   | 64.69                 | 33.58   | 49.14  |
| T <sub>9</sub> | 80.64          | 81.72   | 81.18  | 19.36               | 18.28   | 18.82  | 0.29          | 0.28    | 0.29   | 67.17                 | 35.84   | 51.51  |
| F test         | S              | S       | S      | S                   | S       | S      | S             | S       | S      | S                     | S       | S      |
| S.E.(m)±       | 1.41           | 1.31    | 0.82   | 0.15                | 0.20    | 0.11   | 0.004         | 0.003   | 0.003  | 0.89                  | 0.37    | 0.46   |
| C.D. (P= 0.05) | 4.24           | 3.94    | 2.46   | 0.44                | 0.62    | 0.33   | 0.012         | 0.010   | 0.009  | 2.98                  | 1.12    | 1.40   |

S- Significant, T<sub>0</sub>- Control (no pruning only water spray), T<sub>1</sub>- Retention of 10 cm + 10 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>2</sub>-Retention of 10 cm + 10 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>3</sub> - Retention of 10 cm +10 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>4</sub>- Retention of 15 cm + 20 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>5</sub>- Retention of 15 cm + 20 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>6</sub>- Retention of 15 cm +20 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree), T<sub>7</sub>- Retention of 20 cm + 30 % Fruit Thinning + Amritpani (25 %) + Azotobacter (100 g/tree), T<sub>8</sub>- Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + Azotobacter (100 g/tree), T<sub>9</sub>- Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + Azotobacter (100 g/tree).

## Fruit yield

The perusal of data related to fruit yield (Table 5) clearly revealed that the maximum fruit yield (67.17 kg/tree, 35.84 kg/tree, 51.51 kg/tree) was recorded in mango plants which were treated with the application of T<sub>9</sub>-Retention of 20 cm + 30 % Fruit Thinning + Panchgavya (3 %) + *Azotobacter* (100 g/tree), which was followed by with the application of T<sub>8</sub>-Retention of 20 cm + 30 % Fruit Thinning + Jivamrit (25 %) + *Azotobacter* (100 g/tree) with the value of 64.69 kg/tree, 33.58 kg/tree, 49.14 kg/tree, respectively. The minimum fruit yield (35.94 kg/tree, 12.71 kg/tree, 24.33 kg/tree) was recorded with the T<sub>0</sub>-Control (no pruning, only water spray), respectively in 2023-24, 2024-25 and pooled. This is attributed to the fact that panchgavya contains various micro-organisms, especially bacteria, along with a high concentration of various plant hormones, especially auxins, gibberellins and cytokinins, which improves the fruit plant growth. In addition to this, *Azotobacter* affects plant growth directly by changing the microflora of the rhizosphere and by fixing the atmospheric nitrogen. *Azotobacter* intensifies the activity of rhizosphere microflora involved in ammonification, nitrification, cellulose decomposition and phosphate mineralisation. These findings are consistent with similar studies carried out in strawberry, papaya, guava and mango (14, 38, 40, 44, 45).

## Principal component analysis of various pruning intensities, bio-enhancers and bio-fertiliser application on vegetative growth, flowering and yield of mango cv. Dashehari-51

The first principal component (PC1) had an eigenvalue of 5.35 and accounted for 96.23 % of the total variation, while PC2 contributed 3.13 %, together explaining 99.36 % of cumulative variance (Table 6). Remaining components were negligible, justifying interpretation based on PC1 and PC2 (Table 7 and Fig. 1). PC1 was primarily influenced by negative loadings of plant height (-0.446), canopy height (-0.447), plant spread N-S (-0.455) and E-W (-0.458),

indicating strong structural correlation. Days to shoot emergence (DAP) exhibited a positive loading (+0.415) on PC1, indicating temporal variation independent of plant size. Table 8 presents the loadings of 13 morphological and phenological traits on the first three principal components (PC1, PC2 and PC3) (Fig. 2), derived through principal component analysis (PCA). High-magnitude loadings indicate traits that significantly contribute to the respective principal component. For instance, Days to first flowering, Days to 50 % flowering and Shoot length are strongly associated with PC1, which captures most of the total variation among the treatments. Table 9 combines the explained variance ratios and cumulative variance of the top three principal components with the corresponding trait loadings. PC1 accounts for 97.10 % of the total variability, indicating its dominance in trait separation. The contributions of traits like Flowers per panicle, Inflorescence length and Shoot girth to PC1 and PC2 highlight their influence on multivariate differentiation among treatments.

Principal component loadings of four yield traits (fruit drop, fruit retention, fruit set and fruit yield per tree) (Table 10 and Fig. 3). PC1 exhibited nearly equal and opposite loadings for fruit drop (-0.5006) and fruit retention (+0.5006), while fruit set (+0.4990) and fruit yield (+0.4998) also loaded positively, indicating PC1 captures a comprehensive inverse relationship between fruit drop and productive traits. Eigenvalues and explained variance for the first four principal components derived from standardised yield trait data (Table 11). PC1 had an eigenvalue of 4.3958 and accounted for 98.91 % of the total variance, followed by PC2 (eigenvalue: 0.0383, 0.86 %), PC3 (eigenvalue: 0.0103, 0.23 %), while PC4 explained no further variation. PC1 and PC2 together explained 99.36 % of the total variability. The biplot delineated treatment groupings based on canopy development and shoot emergence timing. Traits associated with plant structure clustered along the negative PC1 axis, while shoot emergence aligned independently on the positive side.

**Table 6.** Eigenvalues, variance explained and cumulative variance for vegetative traits of mango cv. Dashehari-51

| Principal Component | Eigenvalue | Variance Explained (%) | Cumulative Variance (%) |
|---------------------|------------|------------------------|-------------------------|
| PC1                 | 5.35       | 96.23                  | 96.23                   |
| PC2                 | 0.17       | 3.13                   | 99.36                   |
| PC3                 | 0.03       | 0.47                   | 99.83                   |
| PC4                 | 0.01       | 0.14                   | 99.97                   |
| PC5                 | 0          | 0.03                   | 100                     |

**Table 7.** PCA Loadings for vegetative traits of mango cv. Dashehari-51

| Trait                                  | PC1 loading | PC2 loading |
|----------------------------------------|-------------|-------------|
| Plant height (m)                       | -0.454      | 0.187       |
| Canopy height (m)                      | -0.45       | 0.251       |
| Plant spread from N-S (m)              | -0.454      | -0.213      |
| Plant spread from E-W (m)              | -0.434      | -0.765      |
| Days taken to vegetative shoot emerges | 0.444       | -0.52       |

**Table 8.** PCA Loadings for flowering traits of mango cv. Dashehari-51

| Trait                          | PC1 loading | PC2 loading | PC3 loading |
|--------------------------------|-------------|-------------|-------------|
| Duration of flowering (Days)   | -0.279      | -0.030      | 0.111       |
| Days to first flowering        | 0.277       | -0.066      | 0.529       |
| Days to 50 % flowering         | 0.276       | -0.141      | 0.450       |
| Days from flowering to harvest | 0.277       | -0.245      | 0.383       |
| Inflorescence per branch       | -0.278      | -0.376      | 0.173       |
| Panicles per branch            | -0.280      | -0.031      | 0.175       |
| Flowers per panicle            | -0.270      | -0.718      | -0.111      |
| Inflorescence length (cm)      | -0.278      | 0.272       | 0.294       |
| Inflorescence width (cm)       | -0.277      | 0.289       | 0.335       |
| Inflorescence girth (cm)       | -0.277      | -0.191      | 0.029       |
| Leaves per shoot               | -0.278      | 0.242       | -0.023      |
| Shoot length (cm)              | -0.279      | 0.073       | 0.280       |
| Shoot girth (cm)               | -0.280      | 0.001       | 0.089       |

**Table 9.** Eigenvalues, variance explained and cumulative variance for flowering traits of mango cv. Dashehari-51

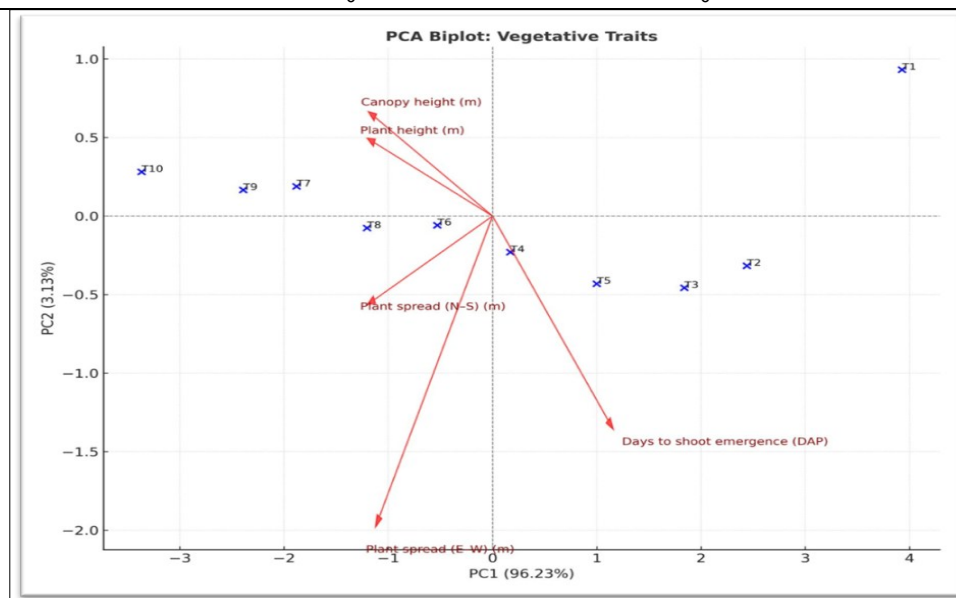
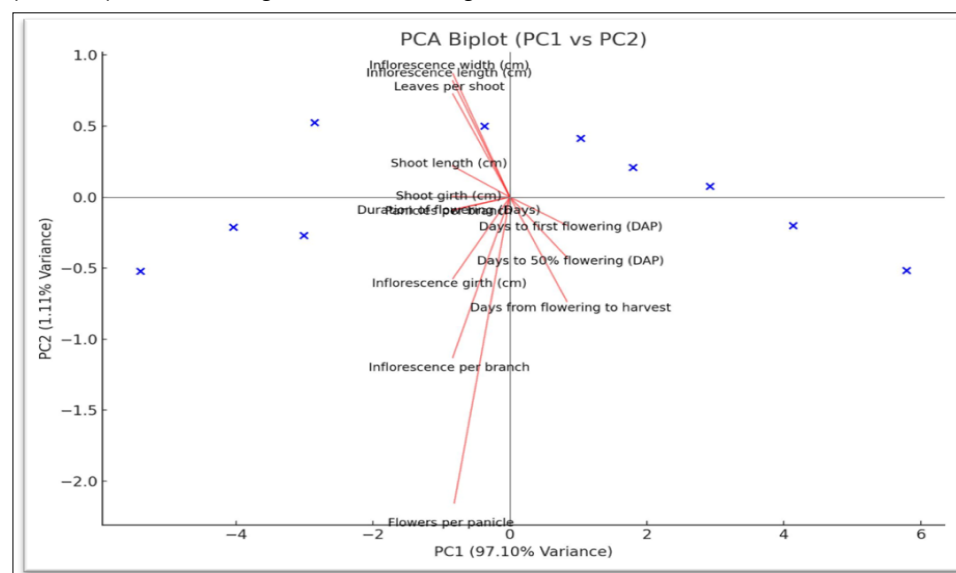
| Principal component | Eigenvalue  | Variance explained (%) | Cumulative variance (%) |
|---------------------|-------------|------------------------|-------------------------|
| PC1                 | 13.95902808 | 0.966394251            | 0.966394251             |
| PC2                 | 0.212984929 | 0.01474511             | 0.981139362             |
| PC3                 | 0.132631991 | 0.009182215            | 0.990321577             |
| PC4                 | 0.050121028 | 0.003469917            | 0.993791494             |
| PC5                 | 0.041757669 | 0.002890916            | 0.99668241              |
| PC6                 | 0.026282954 | 0.001819589            | 0.998501999             |
| PC7                 | 0.012527041 | 0.000867257            | 0.999369255             |
| PC8                 | 0.008057989 | 0.000557861            | 0.999927116             |
| PC9                 | 0.001052767 | 7.29E-05               | 1                       |
| PC10                | 3.26E-29    | 2.26E-30               | 1                       |
| PC11                | 0           | 0                      | 1                       |
| PC12                | 0           | 0                      | 1                       |
| PC13                | 0           | 0                      | 1                       |

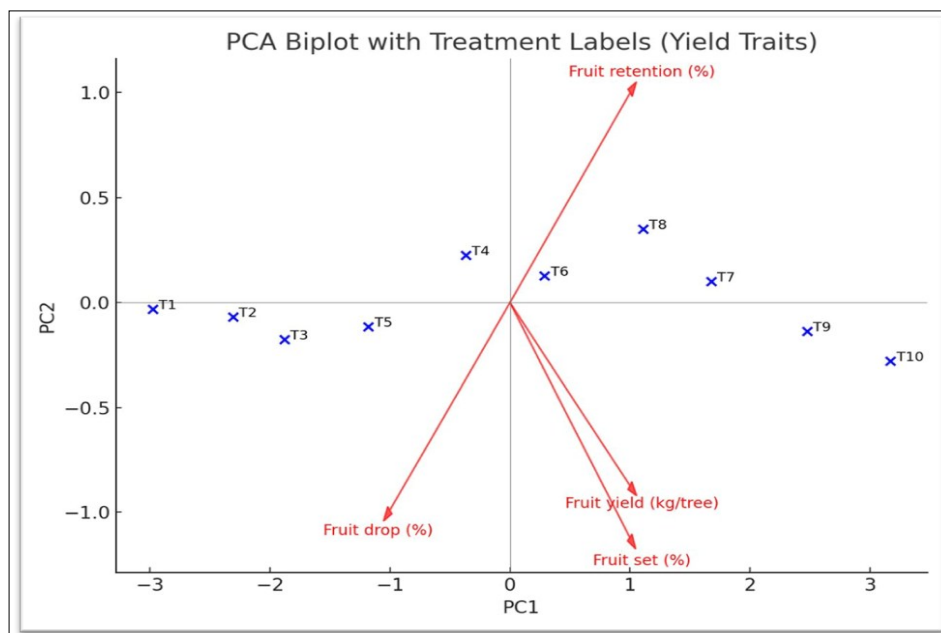
**Table 10.** PCA Loadings for yield traits of mango cv. Dashehari-51

| Trait                 | PC1 loading  | PC2 loading  | PC2 loading  | PC2 loading |
|-----------------------|--------------|--------------|--------------|-------------|
| Fruit drop (%)        | -0.500620427 | -0.495602301 | 0.0426617    | 0.708475495 |
| Fruit retention (%)   | 0.500587955  | 0.499280679  | -0.045554487 | 0.705730325 |
| Fruit set (%)         | 0.498999032  | -0.560757312 | -0.660720205 | 0.000118482 |
| Fruit yield (kg/tree) | 0.499        | -0.436       | 0.748        | 0.002       |

**Table 11.** Eigenvalues, variance explained and cumulative variance for the yield traits of mango cv. Dashehari-51

| Principal component | Eigenvalue | Variance explained (%) | Cumulative variance (%) |
|---------------------|------------|------------------------|-------------------------|
| PC1                 | 4.395791   | 0.989053               | 0.989053                |
| PC2                 | 0.038333   | 0.008625               | 0.997678                |
| PC3                 | 0.01032    | 0.002322               | 1                       |
| PC4                 | 0          | 0                      | 1                       |

**Fig. 1.** Principal component biplot based on vegetative traits of mango cv. Dashehari-51.**Fig. 2.** Principal component analysis (PCA) Biplot (PC1 vs PC2) based on flowering traits of mango cv. Dashehari-51.



**Fig. 3.** Principal component analysis (PCA) Biplot (PC1 vs PC2) based on yield traits of mango cv. Dashehari-51.

The PCA biplot displays the relationship between treatments and 13 quantitative traits in the PC1-PC2 plane. The first principal component (PC1) explains 97.10 % of the total variance, while PC2 accounts for 1.11 %. Blue points represent individual treatments, whereas red vectors denote trait loadings. The direction and length of each vector reflect the influence of that trait on the principal components. Traits such as shoot length, flowers per panicle and panicles per branch showed a strong positive association with PC1, contributing significantly to treatment differentiation. PC1, which explains 98.91 % of the total variation, aligns positively with fruit retention, fruit set and fruit yield and negatively with fruit drop, revealing its central role in treatment differentiation.

## Conclusion

Based on two years of field data and pooled statistical analysis, the study concluded that the treatment T<sub>9</sub>, consisting of retention of 20 cm + 30 % fruit Thinning + panchgavya (3 %) + *Azotobacter* (100 g/tree), was the most effective in enhancing vegetative growth, flowering and yield parameters in mango cv. Dashehari-51. The pruning is an unavoidable necessity of virtually all arboreal fruit crops and is adopted to maintain proper physiological balance between growth and fruiting. Panchgavya have the presence of different important microbes, i.e., aerobic heterotrophic bacteria, lactic acid bacteria, yeast, fungi and anaerobic bacteria, which will boost the growth and enhance the yield also. The study also highlighted that the integrated application of these components was superior to their individual use, suggesting a synergistic interaction that can be leveraged for sustainable and high-quality mango production.

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## Authors' contributions

ST conducted the experiment, carried out the investigation, performed the formal analysis, curated the data and drafted the original manuscript. VKT provided substantial guidance, supervised the study, facilitated the research by offering necessary laboratory facilities, assisted with data analysis, contributed to the methodology and also contributed to the visualisation of the data. SP participated in reviewing and editing the manuscript. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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