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# DELAYED HARVESTING DURING ONE SEASON REDUCES YIELD OF NEXT YEAR'S CROP AND INDUCES ALTERNATE BEARING IN MANGO CV. SAMMAR BAHISHT CHAUNSA

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**Abstract**

Fruit harvesting is traditionally delayed in some mango-producing regions of the world to fetch high fruit prices later in the market. This practice badly affects the fruiting pattern of mango trees during the next crop season. Considering the phenomena, a field-oriented study was carried out in Pakistan to understand the role of different harvesting times on the next year's fruiting. The study was conducted for five consecutive years to properly understand the relationship between harvesting time and the bearing pattern of next year's crop in mango cv. Sammar Bahisht Chaunsa. Mango fruits were harvested at the commercial maturity (CM) stage and followed by 7, 14, 21, and 28 days after CM. The performance of mango plants was evaluated based on their vegetative and reproductive traits as influenced by delayed harvesting. Mango fruits harvested at CM had the highest (72.0%) average postharvest vegetative growth with a maximum (244.1 kg/tree) average fruit yield. In contrast, those harvested 28 days after CM had the lowest (37.5 %) average postharvest vegetative growth with the least (55.6 %) average fruit yield. Delay in the harvesting of mango fruit by 7, 14, 21, and 28 days after CM reduced fruit yield by 16.8, 43.7, 53.9, and 55.6 % when averaged over 5-years data. Harvesting of mango fruit at CM had no bad effects on the next year's mango fruiting. Based on the results from the present investigation, it is suggested that the harvest window of 10-12 days after CM for mango cv. Sammar Bahisht Chaunsa. If harvested within the proposed harvest window, a delay in fruit harvesting does not cause any significant losses in the yield. The trees may prepare themselves efficiently to bear regular fruit crops with minimum risk of developing alternate bearing habits during the subsequent seasons.

**Key words:** Regular fruiting, Harvesting, Fruit-maturity, Postharvest growth, Alternate bearing.

## Introduction

Mango is a major agricultural crop in Pakistan and is an important source of income and nutrition for many farmers and families in the country. It is grown in many parts of Pakistan, including the Punjab, Sindh, and Khyber Pakhtunkhwa provinces. The most common varieties of mangoes grown in Pakistan include the Chaunsa, Dusehri, Langra, and Anwar Ratol. These varieties are known for their sweet, aromatic flesh and thin skin (Usman *et al.*, 2003). Mangoes typically grow in warm, humid climates and require well-draining soil and regular watering. In Pakistan, mangoes are often grown using traditional techniques, such as manual pruning and fertilization, and are vulnerable to pests and diseases, such as the mango hopper and mango malformation disease. Farmers may use various methods to control these issues, including pesticides and integrated pest management techniques (Hussain *et al.*, 2021). Mangoes are a popular fruit in Pakistan and are enjoyed fresh in juices, smoothies, and various dishes and desserts. They are also a key ingredients in many traditional medicines and have been used for centuries to treat various health conditions (Hermann *et al.*, 2022). However, delayed harvesting of mango fruit can have several negative impacts on the quality and yield of the fruit.

Mangoes continue to ripen after being picked, and if they are left on the tree for too long, they may become overripe and develop off flavors and textures. Overripe mangoes are also more prone to deterioration and rot. Delayed harvesting can reducehe overall yield of mangoes, as some of the fruit may become overripe or damaged before it can be harvested (Baloch & Bibi, 2012). Furthermore, late harvesting can also decrease the overall quality of the fruit, as the fruit may become overripe or damaged before it is harvested. This can lead to a decrease in the marketability of the fruit and a reduction in the price that farmers can receive for their crop. It increases the risk of pests and diseases, as the fruit may be more vulnerable to infestation or infection as it becomes overripe (Baloch & Bibi, 2012).

Judicious understanding of tree phenology and various physiological events which lead the tree to optimum and regular fruiting such as vegetative growth, root growth, dormancy, bud induction and differentiation, flowering, fruit setting and development of fruit plays a vital role in successful mango orchard management (Ramírez *et al.*, 2014; Makhmale *et al.*, 2016; Prates *et al.*, 2021). One of the most important physiological processes is the initiation of shoot growth in the buds of resting stems in order to produce flowering (Ravishankar *et al.*, 2021). Mature vegetative growth is the basic principle fruiting area for many mango varieties while age and the maturity level of vegetative flushes are the critical components of regulating floral bud induction in mango (Clonan *et al.*, 2021). Old and well-mature vegetative flushes induce heavy blooming in a mango tree. Bud induction is basically a process in which buds stimulate the specific types of shoots such as vegetative (vegetative induction), generative (floral induction) and/or mixed (combined vegetative-floral induction) shoots (Capelli *et al.*, 2021; Prates *et al.*, 2021). Time of fruit harvest for the previous season's crop and the onset of dry and wet seasons that influence the process of bud induction are some of the important factors which decide the initiation of flowering in mango trees. Similarly, the time of emergence of postharvest vegetative growth and its vigor decides the fate of next year's flowering and fruiting. It has been observed that delay in harvesting of mango crop results in poor emergence of postharvest vegetative flushes thereby reducing flowering and fruiting during the next season (Soudagar *et al.*, 2018).

Alternate bearing, also known as biennial bearing, is a pattern of heavy fruit production one year followed by a year with little or no fruit production in mango trees. This can be a problem for growers as it can lead to inconsistent fruit production and potentially lower yields. There are several factors that can contribute to alternate bearing in mango trees. These include:

**1. Nutrient imbalance:** Mango trees that are deficient in certain nutrients, such as nitrogen and potassium, may be more prone to alternate bearing.

**2. Water stress:** Mango trees that are subjected to periods of drought or overly wet conditions may experience alternate bearing.

**3. Pest and disease pressure:** Pests and diseases can weaken mango trees and make them more susceptible to alternate bearing.

**4. Cultural practices:** Poor pruning practices or overloading the tree with too much fruit can lead to alternate bearing.

**5. Environmental conditions:** Extreme temperatures or changes in temperature can affect the tree's ability to produce fruit consistently.

To help prevent or mitigate the effects of alternate bearing, mango trees can be fertilized with a balanced fertilizer that includes sufficient amounts of nitrogen and potassium, and irrigation should be managed to avoid drought or waterlogging. Pest and disease management is also important, as is proper pruning and training of the tree to ensure an optimal balance between vegetative growth and fruit production (El-Motaium *et al.*, 2019; Shivran *et al.*, 2020).

There is some evidence to suggest that delayed harvesting of mango fruit can contribute to alternate bearing in the tree. Alternate bearing, also known as biennial bearing, is a pattern of heavy fruit production one year followed by a year with little or no fruit production. When mango fruit are left on the tree for an extended period of time, they continue to mature and ripen, which can lead to an increased demand for resources such as water and nutrients from the tree. This can result in a reduction in vegetative growth and flower production, leading to a decrease in fruit production the following year (Barman & Mishra, 2018). On the other hand, if mango fruit are harvested at the appropriate time, it can help to balance the demand for resources and promote more consistent fruit production from year to year. In general, it is recommended to harvest mango fruit when they are fully mature but still firm, as this allows for better postharvest handling and storage. It is worth noting that there are many other factors that can also influence alternate bearing in mango trees, including the age and health of the tree, cultural practices, and environmental conditions (Yeshitela *et al.*, 2005).

As the practice of delayed harvesting ultimately causes the mango tree to develop alternate bearing habit. Harvesting of mango crop is intentionally delayed in some regions of Pakistan to fetch high market prices without knowing the ill-effects of the practice. That's why the current 5-year study was, aimed at investigating the effects of delayed harvesting of mango fruit during one season on the postharvest vegetative growth, flushes April and flowering and fruiting pattern of mango trees during the next season. The objective of the investigation was to determine the optimum time of fruit harvesting in mango cv. Sammar Bahisht Chaunsa to ensure regular fruiting every year. This study was planned to cover the knowledge gap regarding the impact of delay harvesting on alternate bearing of mango because of limited availability of literature on this topic. It is hypothesized that delay harvesting in mango might be imperative in its role for providing facilitation to alternate bearing in mango.

## Materials and Methods

The trial was conducted at Mango Research Station Shujabad (located at 29º 52'55.818" N to 71º 21'12.318" E), on the 25-years old mango trees cv. Sammar Bahisht Chaunsa, planted at a distance of 12m (40 feet) between rows and plants. The experimental area receives annually 175 mm rainfall with an average annual temperature of 25.6°C. Soil of experimental site was loamy and alkaline in nature having soil pH more than 8.0. The investigation extended over five consecutive seasons from 2015 to 2020. After fruit harvesting in 2015, the experimental trees were pruned to maintain the volume of their canopy every year. They were managed at 8 m height with the canopy radius of 5.3 m. Immediately after fruit harvesting under each treatment, each tree was supplied with the regionally standard nutrients of NPK (1 kg each). An additional dose of N (500 g) was applied to each experimental tree during flowering ($1^{st}$ week of March) each year. The experimental trees were irrigated by flooding as and when required. However wet soils were never irrigated and no irrigation was applied during peak winter (November and December) each year.

The fruit were harvested at 0, 7, 14, 21 and 28 days after commercial maturity (CM) to evaluate the effects of different maturity stages on the pattern of next year's crop. CM was confirmed by checking the total soluble solids (TSS) of mango fruit while those which attain the TSS level of 13 $^{o}$BRIX are considered to be commercially mature. Data on vegetative and reproductive growth of experimental trees were recorded during experiment:

**Vegetative growth:** The crop was harvested in July-August and postharvest growth was measured in October by using the 'Ring' method (Sarker & Rahim, 2012). The plants under experiment were harvested at different levels as required under different treatments and first data of postharvest vegetative growth was recorded in October 2015 while the first yield data was recorded in July-August 2016. A wooden ring of known diameter (approx. 1.5m) was used to measure the growth intensity of experimental trees. The ring was placed at 20 different locations randomly selected at different heights all around the tree. The vegetative terminals (growing/full grown) were counted inside the ring. Similarly total terminals inside the ring were also counted to calculate and express the growing terminals in percentage by using the following formula:

$$\text{Growing terminals (\%)} = \frac{\text{Growing terminals inside the ring}}{\text{Total terminals inside the ring}} \times 100$$

**Reproductive growth and fruit yield:** The flowering intensity was recorded for each experimental tree during the 4$^{th}$ week of March each year during investigation by using the Ring method as detailed above. The first flowering and yield data was recorded in March and July-August 2016, respectively. All the fruits on the tree were harvested and counted. The fruit yield was recorded by weighing all the fruits in kg/tree (UWE-ESP 5). Total number of fruits harvested from each replication were counted and the average fruit yield was expressed in grams.

**Total soluble solids (TSS) and titratable acidity (TA):** TSS of mango juice taken from 20 individual ripe fruit from each replication was detected by using a digital refractometer (ATAGO, RS- 5000) and the average value was expressed in $^{O}$BRIX. To estimate TA, 5 ml mango juice was separately squeezed from each of 20 fruit per replication taken in a 10-ml flask and the volume was made up to the mark by adding distilled water. Added 2-3 drops of phenolphthalein to the juice. The juice was titrated against 0.1 N NaOH till the development of pink color. TA of mango juice expressed in percentage (%) and calculated using the following formulae (Qureshi *et al.*, 2021).

$$\text{TA (\%)} = \frac{0.1 \text{ N NaOH} \times 0.0064}{\text{Volume of juice used}} \times 100$$

**Statistical analysis**

Experiment was laid out according to Randomized Complete Block Design with five treatments and six replications keeping two plants in each replication as an experimental unit. Collected data were analyzed statistically by analysis of variance over the year technique (Steel *et al.,* 1997). Comparisons among the means were made by LSD test at $p \leq 0.05$.

**Results and Discussion**

**Postharvest vegetative growth:** Postharvest growth on fruiting terminals is a basic flowering and fruiting area on plants for next year's flowering and fruit setting in mango cultivar. Chaunsa producing the regular crop. An enhanced intensity of vegetative growth in bearing mango trees immediately after fruit harvesting results in optimum yield in the next year (Davenport, 2000). Effects of delayed harvesting on postharvest vegetative growth of mango trees were recorded for five consecutive years (2015-2019) (Table 1). Maximum postharvest vegetative growth (72.0%) was recorded in mango trees where the fruit were harvested at CM. The trees from which the fruit were harvested at 7, 14, and 21 days following CM depicted 62.7, 47.4, and 40.7% reduce in postharvest vegetative growth, respectively. The least postharvest vegetative growth (37.5%) was recorded in mango trees from which the fruit were harvested at 28 days after CM. Parallel plots for postharvest maturity is provided in Fig. 1. Scale bar is showing the values of data range (0-79).

Mango trees prepare themselves for new vegetative growth when they are low in growth inhibitors. Delayed harvesting causes growth inhibitors to increase in the trees which further delays the process of stimulating postharvest vegetative growth. Due to delayed harvesting, the fruits that stays on the tree keep on adding and passing on the growth inhibitors towards their respective shoots. As a result, emergence of postharvest growth is badly reduced. Generally, a healthy non-fruiting mango shoot may complete four to five flushing episodes in one season (Nunez-Elisea & Davenport, 1992; Nunez-Elisea *et al.*, 1996). Many of these non-fruiting shoots remain unable to induce flowering during the following season (Issarakraisila *et al.*, 1991). Harvesting of mango fruit at CM causes vegetative growth to induce earlier and the shoots become mature prior to flowering which lately results in heavy flower induction in mango trees (Hahn *et al.*, 2022). A similar suggestion was made by Ravishankar *et al.*, (2021). He reported that older and more mature flushes accumulate sufficient reserves of carbohydrates to attain physiological maturity which is primarily required for fruit bud differentiation and subsequently for flowering. Early vegetative growth in Sammar Bahisht Chaunsa is vigorous and competent for flowering during the next spring season which may only be achieved by judicious fruit harvesting at an appropriate maturity. Delayed harvesting not only reduces the intensity of growing terminals but also deteriorates the vigor of resulting shoots (Rademacher, 2015). In general, most of these shoots fail to acquire proper maturity required to induce flowering during next spring.

**Table 1. Effects of delayed harvesting on postharvest growth of mango trees.**

| Harvest maturity (Days after CM) | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
|---|---|---|---|---|---|---|
| 0 | 79.2$^{a}$ | 57.2$^{b}$ | 78.1$^{a}$ | 66.5$^{a}$ | 79.2$^{a}$ | 72.0$^{A}$ |
| 7 | 71.2$^{b}$ | 45.5$^{c}$ | 70.4$^{b}$ | 54.8$^{c}$ | 71.4$^{b}$ | 62.7$^{B}$ |
| 14 | 53.5$^{c}$ | 64.9$^{a}$ | 37.5$^{c}$ | 39.7$^{d}$ | 41.4$^{c}$ | 47.4$^{C}$ |
| 21 | 31.7$^{d}$ | 58.8$^{b}$ | 24.9$^{d}$ | 60.6$^{b}$ | 27.6$^{d}$ | 40.7$^{D}$ |
| 28 | 24.6$^{e}$ | 65.5$^{a}$ | 14.8$^{e}$ | 66.1$^{a}$ | 16.5$^{e}$ | 37.5$^{E}$ |

**Table 2. Effects of delayed harvesting on April growth of mango trees.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average |
|---|---|---|---|---|---|---|
| 0 | 7.1$^{d}$ | 9.4$^{b}$ | 10.5$^{c}$ | 12.5$^{b}$ | 10.4$^{c}$ | 10.0$^{D}$ |
| 7 | 10.3$^{c}$ | 15.3$^{a}$ | 10.6$^{c}$ | 14.2$^{a}$ | 9.4$^{c}$ | 12.0$^{C}$ |
| 14 | 15.5$^{a}$ | 8.1$^{c}$ | 14.3$^{b}$ | 10.3$^{c}$ | 13.6$^{b}$ | 12.4$^{AB}$ |
| 21 | 14.4$^{b}$ | 8.2$^{c}$ | 16.4$^{a}$ | 10.4$^{c}$ | 13.7$^{b}$ | 12.6$^{AB}$ |
| 28 | 16.3$^{a}$ | 6.1$^{d}$ | 17.1$^{a}$ | 10.1$^{d}$ | 18.7$^{a}$ | 13.7$^{A}$ |

**Table 3. Effects of delayed harvesting on flowering terminals (%) of mango.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average |
|---|---|---|---|---|---|---|
| 0 | 71.1$^{a}$ | 63.8$^{a}$ | 77.3$^{a}$ | 61.3$^{a}$ | 74.1$^{a}$ | 69.5$^{A}$ |
| 7 | 59.3$^{b}$ | 52.7$^{b}$ | 64.6$^{b}$ | 53.4$^{b}$ | 65.3$^{b}$ | 59.1$^{B}$ |
| 14 | 31.6$^{c}$ | 42.6$^{c}$ | 34.6$^{c}$ | 44.5$^{c}$ | 36.4$^{c}$ | 37.9$^{C}$ |
| 21 | 28.7$^{d}$ | 43.5$^{d}$ | 29.8$^{d}$ | 46.5$^{d}$ | 26.5$^{d}$ | 35.0$^{D}$ |
| 28 | 23.8$^{e}$ | 45.1$^{e}$ | 24.1$^{e}$ | 44.2$^{e}$ | 25.4$^{e}$ | 32.5$^{E}$ |

**April flush:** An antagonistic relationship was observed between postharvest vegetative growth and April flush in mango plants, during present investigation (Table 2). Reduced postharvest vegetative growth and flowering resulted in higher intensity of April flush in mango trees. Maximum April growth (13.7%) was recorded in mango trees where the fruit were harvested at 28 days after CM. Delay (28 days) in harvesting of fruits decreased the emergence of postharvest growth (37.5%) while increased the emergence of April growth (13.7%). The least April flush (10.0%) was recorded in mango trees from which the fruits were harvested at CM. Parallel plots for April flushes is provided in Fig. 2. Scale bar is showing the values of data range (0-19). Majority of the terminals recorded in present investigation produced vegetative/ fruiting shoots in the spring season. This is because the spring is the time of year when trees begin to grow new leaves and flowers, and it is also the time when they start to produce fruit. The exact timing of this process can vary depending on the specific species of tree and the local climate. Some trees may start to produce vegetative and fruiting shoots earlier in the spring, while others may start later. In general, the spring is a time of growth and renewal for trees, and it is a key period in their annual life cycle (Breen *et al.,* 2020). More the postharvest vegetative growth in mango trees, more was the flowering. It resulted in lesser number of terminals left on the tree to grow vegetatively during the spring season (Davenport, 2007).

**Flowering terminals:** Percentage of flowering terminals on experimental mango trees was recorded for five consecutive years (2016-2020) by the ‘Ring’ method (Table 3). Effects of delayed harvesting on next year’s flowering were recorded. The maximum flowering terminals (69.5 %) were recorded in the trees from which the fruit were harvested at CM. A strong positive relationship was observed between postharvest vegetative growth and flowering terminals in mango trees. Fruit harvesting at 7 days after CM depicted 59.1% flowering. Delay of fruit harvesting by 14, 21 and 28 days from CM resulted in 37.9%, 35.0% and 32.5% flowering terminals, respectively. It was found that delay in harvesting severely affected the next year flowering capacity of mango plants. Parallel plots for flowering terminals are provided in Fig. 3. Scale bar is showing the values of data range (0-77).

Fruit yield is the direct outcome of two major phenological stages of plants i.e., flowering and fruit setting. Flowering was observed on well-developed and mature vegetative flushes which were induced after the fruit harvesting during the last year. During the flowering stage, a plant will produce flowers, which are the reproductive structures that contain the plant's sexual organs. The flowers are important for sexual reproduction because they produce pollen, which is needed for fertilization (Cronk, 2022). Early postharvest growth found to have more tendency of producing flowers whereas delayed growth had lesser tendency which was directly dependent on the crop harvesting time. Maturity of vegetative flushes and accumulation of carbohydrates in mango shoots is primarily associated with synthesis of floral flushes (Chacko, 1991) which ultimately increases the flowering tendency in earlier induced vegetative flushes. It results in an enhanced induction of mango inflorescence (Monselise & Goldschmidt, 1982).

**Fruit yield:** Fruit yield of mango trees was strongly influenced by the stage of their maturity at harvest. Fruit harvesting within a shorter harvest window (i.e., 7 days) following the CM maintained higher yields with minimal fluctuations over the next four consecutive seasons (2017-2020) (Table 4). It suggests that earlier is the harvesting of mango fruit, better is the yield in the next season while delay of fruit harvesting results in subsequent reduction in yield. When taking the average of 5 years of data on fruit yield, it was observed that harvesting of all mango fruit at CM during the previous year resulted in higher yield (i.e., 244.1 kg /plant) compared to other treatments, during the next year (Table 4). Delay in harvesting by 7, 14, 21 and 28 days from CM reduced the yield by 16.8, 43.7, 53.9, and 55.6 % respectively. The results from the present five years investigation indicated that delay in harvesting beyond the CM induced alternate bearing habit in mango cv. Sammar Bahisht Chaunsa. Delayed harvesting reduces the next year fruiting tendency of mango plants. However, there is a window of 10-12 days from the time of commercial maturity which does not causes any significant reduction in postharvest growth and next year’s fruiting. Parallel plots for fruit yield is provided in Fig. 4. Scale bar is showing the values of data range (0-275).

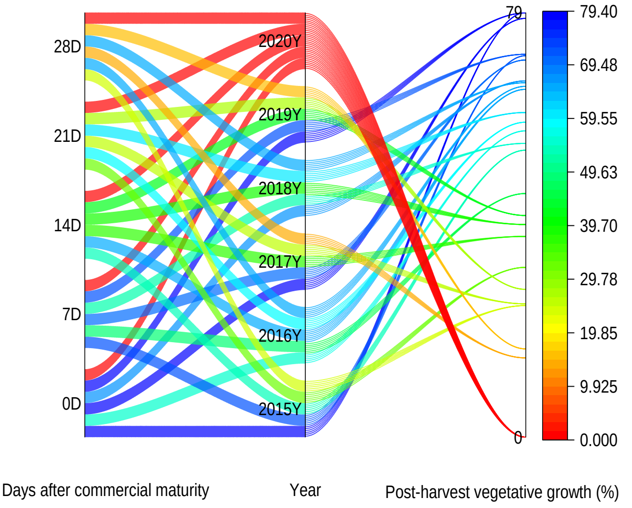


Fig. 1. Parallel plots for postharvest maturity. Scale bar is showing the values of data range.

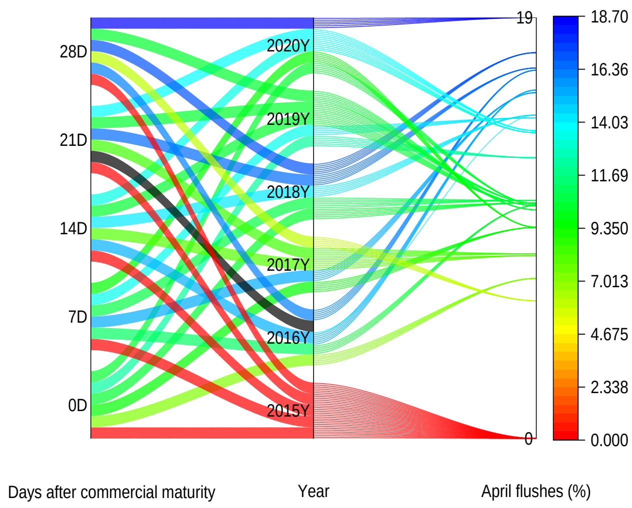


Fig. 2. Parallel plots for April flushes. Scale bar is showing the values of data range.

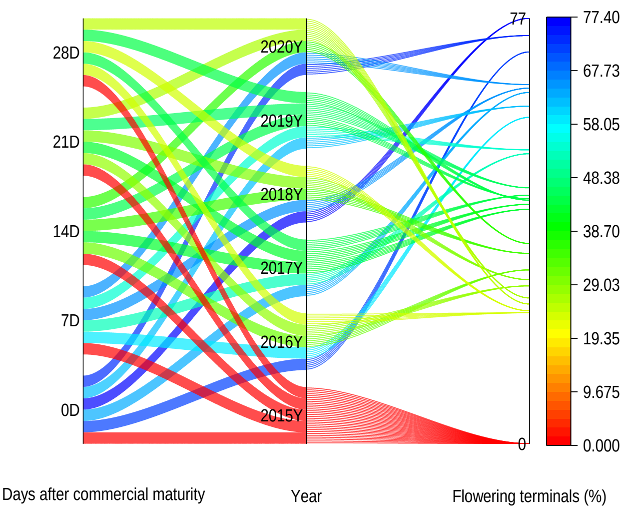


Fig. 3. Parallel plots for flowering terminals. Scale bar is showing the values of data range.

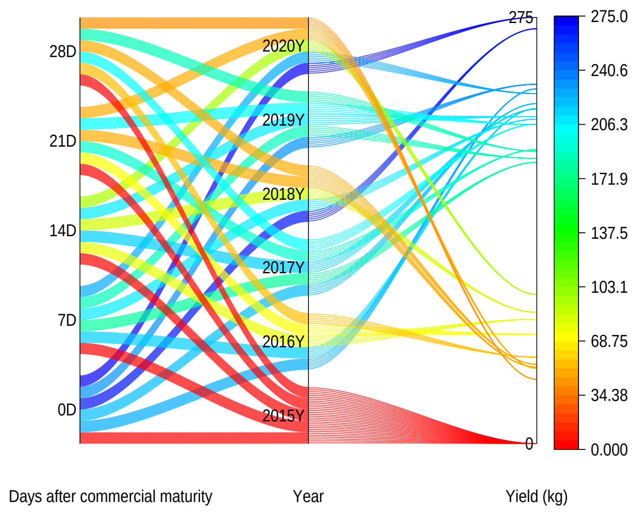


Fig. 4. Parallel plots for fruit yield. Scale bar is showing the values of data range.

**Table 4. Effects of delayed harvesting on yield (Kg) of mango.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average | % Decrease in yield |
|---|---|---|---|---|---|---|---|
| 0 | 228.4$^{a}$ | 218.9$^{a}$ | 267.1$^{a}$ | 231.4$^{a}$ | 274.5$^{a}$ | 244.1$^{A}$ | 0 |
| 7 | 215.7$^{b}$ | 181.1$^{b}$ | 208.9$^{b}$ | 183.7$^{b}$ | 225.3$^{b}$ | 202.9$^{B}$ | 16.8 |
| 14 | 80.1$^{c}$ | 215.4$^{c}$ | 84.6$^{c}$ | 210.6$^{c}$ | 96.1$^{c}$ | 137.4$^{C}$ | 43.7 |
| 21 | 70.4$^{d}$ | 189.2$^{d}$ | 49.3$^{d}$ | 205.4$^{d}$ | 48.6$^{d}$ | 112.6$^{D}$ | 53.9 |
| 28 | 55.7$^{e}$ | 205.7$^{e}$ | 51.1$^{e}$ | 188.3$^{e}$ | 41.4$^{e}$ | 108.4$^{E}$ | 55.6 |

The values followed by different letters in the same column indicate significant differences (Tukey test, $p \leq 0.05$); CM = Commercial maturity

**Table 5. Effects of delayed harvesting on Average Fruit weight (g) of mango.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average |
|---|---|---|---|---|---|---|
| 0 | 210.5$^{e}$ | 213.2$^{e}$ | 210.4$^{e}$ | 224.2$^{e}$ | 221.5$^{e}$ | 216.0$^{E}$ |
| 7 | 218.7$^{d}$ | 210.1$^{d}$ | 219.6$^{d}$ | 241.6$^{d}$ | 233.2$^{d}$ | 224.6$^{D}$ |
| 14 | 230.1$^{c}$ | 224.2$^{c}$ | 246.8$^{c}$ | 259.2$^{c}$ | 240.8$^{c}$ | 240.2$^{C}$ |
| 21 | 247.5$^{b}$ | 238.5$^{b}$ | 244.8$^{b}$ | 259.7$^{b}$ | 258.2$^{b}$ | 249.7$^{B}$ |
| 28 | 260.6$^{a}$ | 269.3$^{a}$ | 257.5$^{a}$ | 263.8$^{a}$ | 261.5$^{a}$ | 262.5$^{A}$ |

The values followed by different letters in the same column indicate significant differences (Tukey test, $p \leq 0.05$); CM = Commercial maturity

**Table 6. Effects of delayed harvesting on TSS (°BRIX) of mango.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average |
|---|---|---|---|---|---|---|
| 0 | 24.1[a] | 24.2[a] | 25.2[a] | 25.1[a] | 25.3[a] | 24.8[A] |
| 7 | 25.3[a] | 25.7[a] | 25.2[a] | 25.1[a] | 25.4[a] | 25.3[A] |
| 14 | 25.2[a] | 25.9[a] | 26.4[a] | 26.4[a] | 26.6[a] | 26.1[A] |
| 21 | 26.4[a] | 26.3[a] | 26.6[a] | 26.1[a] | 26.4[a] | 26.4[A] |
| 28 | 26.7[a] | 27.8[a] | 26.6[a] | 26.4[a] | 26.6[a] | 26.8[A] |

The values followed by different letters in the same column indicate significant differences (Tukey test, $p \leq 0.05$); CM = Commercial maturity

**Table 7. Effects of delayed harvesting on TA (%) of mango.**

| Harvest maturity (Days after CM) | 2016 | 2017 | 2018 | 2019 | 2020 | Average |
|---|---|---|---|---|---|---|
| 0 | 0.9[a] | 1.01[a] | 0.83[a] | 0.75[a] | 0.88[a] | 0.87[A] |
| 7 | 1.01[a] | 0.98[a] | 0.95[a] | 1.03[a] | 0.98[a] | 0.99[A] |
| 14 | 0.86[a] | 0.83[a] | 0.87[a] | 0.8[a] | 0.88[a] | 0.85[A] |
| 21 | 0.74[a] | 0.78[a] | 0.79[a] | 0.77[a] | 0.74[a] | 0.76[A] |
| 28 | 0.65[a] | 0.51[a] | 0.65[a] | 0.69[a] | 0.65[a] | 0.63[A] |

The values followed by different letters in the same column indicate significant differences (Tukey test, $p \leq 0.05$); CM = Commercial maturity

The optimum and regular fruit yield of each tree is an ultimate desire of the farming community. It is a common observation that whenever mango plants cv. Sammar Bahisht Chanusa bear heavy fruit in one year mostly follows by lower yield next year. This is due to the delayed harvesting of mango fruits in “on year”. Due to late harvesting, there is poor and/or postharvest vegetative growth on plants, which leads to poor flowering and fruit setting and ultimately less yield in the next year. While harvesting of fruits at initial maturity stage, initiates the vegetative growth quiet early which bears more potential to induce flowering in the next year because mango plant cv. Sammar Bahisht Chanusa bears flowering on properly matured vegetative flushes (Núñez-Elisea & Davenport, 1995). Previous findings also revealed that induction of flowering and fruit setting are dependent on age of the vegetative flushes, mature flushes bear heavy fruit setting because of having more reserves of carbohydrates promoter and vice versa (Davenport, 2000, 2003).

**Average fruit weight:** The highest average weight (262.5 g) fruit was recorded for the fruit harvested 28 days following the CM during the previous year. The fruit harvested at CM had the lowest (i.e., 216.0 g) fruit average weight (Table 5). When fruit get matured on the plant, no further increase in its size was noted, irrespective of the treatments. The fruit size was found dependent on the crop load. The higher the crop load, smaller was the fruit size (Table 5). Parallel plots for average fruit weight is provided in Fig. 5. Scale bar is showing the values of data range (0-270).

**TSS and TA:** The TSS of mango fruit was slightly increased by delay in harvesting. The fruit harvested at CM had the lowest average TSS (24.8 °Brix) whereas those harvested at 28 days from CM had the highest (26.8 °Brix) average value of TSS. The slight variation in TSS was also noted from year to year as evident from the results (Table 6). A similar trend of variation in TA of mango fruit was observed (Table 7). TA of mango fruit ranged between 0.8 and 1.0 %, regardless of the treatments.

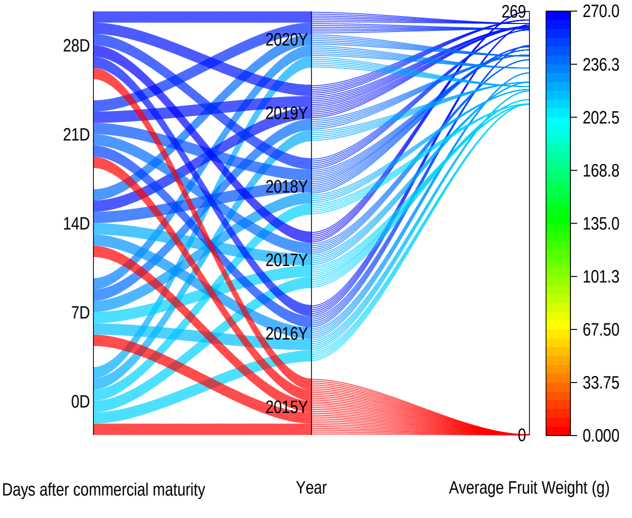


Fig. 5. Parallel plots for average fruit weight. Scale bar is showing the values of data range.

## Conclusion

It is concluded that harvesting mango fruits at a certain time referred to as CM can significantly increase fruit yield the following year. This time period, CM, also results in maximum postharvest growth, which is important for fruiting the next year. It is suggested that harvesting mango fruits within a certain window of time, possibly 10-12 days after CM, will not cause significant economic loss for the grower and can prevent the development of an "alternate bearing habit" in mango trees. This means that instead of having heavy fruiting one year and lighter fruiting the next, the mango trees will be efficiently prepared for heavy fruiting the following year.

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