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Influence of Pruning Time and Intensity on Flowering Synchronization in Ber (*Ziziphus mauritiana* Lam.)

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Abstract

Ziziphus mauritiana Lam., commonly known as ber, is an important fruit crop in India; however, its productivity is often constrained by asynchronous flowering. This study investigates the effects of pruning time (February to May) and pruning intensity (light: 25%, moderate: 50%, heavy: 75% shoot removal) on flowering synchronization under the subtropical conditions of Bhopal. A two-year field experiment was conducted using a randomized complete block design (RCBD) on 'Gola' cultivar trees. The results indicated that moderate pruning performed in mid-March led to the highest flowering synchronization, with an 87% overlap in bloom period, representing a 22% improvement over unpruned controls (65%). In contrast, late pruning in May significantly reduced synchronization to 52% and delayed the onset of flowering by approximately 10 days. Heavy pruning favored vegetative growth, resulting in reduced floral overlap (58%). Light pruning in March enhanced flower production, averaging 48 flowers per shoot compared to 40 in the control. Additionally, moderate pruning extended the bloom duration by seven days. These findings suggest that moderate pruning in early spring effectively aligns bud break with resource availability post-dormancy, thereby enhancing floral synchrony. The study provides practical insights for improving ber orchard productivity in Central India, though cultivar-specific responses should be further examined.

Introduction

Ber (*Ziziphus mauritiana* Lam.),

widely recognized as Indian jujube, is a hardy, multipurpose fruit crop that holds critical ecological and economic importance in the semi-arid and arid regions of India. It exhibits remarkable adaptability to extreme temperatures, drought conditions, and degraded soils, making it one of the few viable fruit crops for marginal agricultural zones. In Madhya Pradesh, ber plays a central role in sustaining the livelihoods of approximately 50,000 smallholder farmers (State Horticulture Report, 2023). Beyond its agronomic value, ber contributes significantly to nutritional security due to its high vitamin C content and its suitability for both fresh consumption and processing. Its fruits, leaves, and wood also serve as vital resources in rural households for food, fodder, and fuel.

However, despite its resilience and socioeconomic value, the productivity of ber remains inconsistent, largely due to its poorly synchronized flowering behavior. Asynchronous flowering—where individual trees or branches within the same orchard initiate blooming at different times—disrupts the synchrony needed for efficient pollination. Since ber is primarily pollinated by wind and insects, including *Apis* spp. and *Chrysomya* flies, overlapping bloom periods among trees are essential to ensure cross-pollination. Lack of synchrony leads to scattered and incomplete fruit set, ultimately contributing to yield losses estimated between ₹120–150 million annually in Madhya Pradesh alone (State Horticulture Report, 2023).

Ecological and Economic Significance

Ber's ecological footprint in India is substantial. It thrives on minimal water input, flourishes in saline and rocky soils, and contributes to biodiversity in agroforestry systems. In the face of climate variability, its stable phenological rhythm and drought resilience make it an insurance crop for risk-prone farmers. Economically, ber orchards provide income in otherwise low-productivity seasons. Yet, this potential is curtailed by irregular and prolonged blooming patterns, which also complicate harvest planning, increase labor costs, and reduce market- grade uniformity in fruit quality. Thus, synchronizing flowering across trees within orchards emerges as a crucial management objective to stabilize both yield and quality.

Physiological Basis of Pruning Effects

Pruning is one of the few orchard management practices that can directly influence reproductive phenology in perennial fruit crops. It functions not only as a structural intervention but also as a physiological trigger. Mechanistically, pruning modifies the hormonal balance within the tree—primarily by reducing apical dominance and altering the auxin- to-cytokinin ratio (Gomez-Cadenas et al., 2022). The removal of shoot apices decreases auxin levels in the vascular stream, which in turn lifts the inhibition on lateral bud development and enhances cytokinin synthesis in roots. This hormonal shift facilitates the activation of latent floral buds, particularly in species with indeterminate growth habits such as ber. In addition to hormonal dynamics, pruning affects carbohydrate allocation by redistributing photosynthates toward newly emerging sinks, which may include both vegetative shoots and floral primordia. The extent and direction of this redistribution depend significantly on pruning intensity. Light pruning may fail to disrupt existing hormonal patterns, while heavy pruning often prioritizes vegetative regrowth, delaying reproductive development. Moderate pruning is generally associated with a balanced regrowth response that supports both shoot renewal and floral differentiation.

In subtropical climates like Bhopal, thermal time accumulation following pruning acts as an external modulator of this internal physiological process. The pruning-induced hormonal shifts must coincide with favorable temperature regimes to successfully transition buds from vegetative to reproductive fate. For instance, pruning conducted too early in the season (e.g., February) may result in vegetative flushes susceptible to late frost or drought, while delayed pruning (e.g., May) may shift flowering beyond the optimal pollination window, coinciding with the onset of high humidity or pest pressures.

Research Gap

The influence of pruning on flowering behavior has been extensively studied in temperate fruit crops, particularly those with determinate flowering patterns. For example, in apple, Tromp (2020) demonstrated that shoot pruning alters return bloom via its impact on shoot vigor and light distribution. Similar findings exist for grapevine, peach, and guava (Sharma et al., 2018), where pruning has been strategically used to manipulate phenological events and synchronize fruiting.

However, *Ziziphus mauritiana* exhibits several unique traits that limit the direct applicability of temperate crop models. Its flowering is indeterminate, meaning floral buds can arise continuously over an extended period under favorable conditions. Furthermore, its response to pruning is modulated by highly seasonal rainfall patterns, which influence dormancy release and subsequent bud break. As such, pruning protocols developed for temperate species or even for tropical perennials like mango cannot be reliably transferred to ber without climate-specific and species-specific adaptation.

In India, particularly in Central India's subtropical regions, few studies have systematically explored the combined effects of pruning time and intensity on flowering synchronization in ber. Most available literature focuses on growth or yield parameters independently, without quantifying synchronization as a distinct metric. Moreover, research trials often span only a single season, failing to capture inter-annual variability in climatic responses.

Novelty of the Present Study

This study addresses the aforementioned gaps by introducing a novel, quantitative approach to evaluating flowering synchronization in ber orchards. For the first time, bloom overlap percentage (%) is employed as a synchronization metric, enabling a more precise comparison across treatments. By analyzing the temporal overlap of flowering periods among trees, this metric directly correlates with pollination efficiency and potential fruit set.

Furthermore, the study integrates

pruning intensity levels (light, moderate, heavy) with pruning timings ranging from February to May, against the backdrop of monsoonal phenology. This integrative approach allows for a comprehensive understanding of how internal tree physiology and external climatic variables interact to shape flowering behavior.

Objectives

The present investigation was designed with three main objectives:

1. To determine the effect of pruning time on the degree of bloom overlap and synchronization among ber trees.
2. To assess how varying pruning intensities influence the balance between vegetative and productive growth.
3. To generate actionable management recommendations for ber orchardists in subtropical climates, particularly in Central India.

Hypothesis

It is hypothesized that **moderate pruning (50% shoot removal) conducted in early spring (March)** will yield the highest flowering synchronization. This timing is expected to align with the natural dormancy release and thermal accumulation, optimizing hormonal signals for floral induction and ensuring temporal overlap of bloom periods across trees.

Materials and Methods

Study Site and Climatic Conditions

The study was conducted over two consecutive growing seasons (2022–2024) in a managed ber (*Ziziphus mauritiana* Lam.) orchard located in the Bhopal district of Madhya Pradesh, India (23.25°N, 77.41°E; elevation: 527 m). The region falls under a semi-arid subtropical climate, characterized by hot summers, a pronounced monsoon season (June–September), and mild winters. The experimental site was situated within a 1- hectare research block maintained under the aegis of a state horticultural research station.

Meteorological data were collected from an automatic weather station located within 1 km of the trial site. During the experimental period, mean monthly temperatures ranged from 18°C in February to 34°C in May, with relative humidity (RH) varying between 45% and 80%. Pre-monsoon rainfall during the experimental window was minimal (<30 mm total), enabling precise irrigation control. A uniform drip irrigation system was applied across all blocks to prevent drought stress. Sunshine hours increased steadily from approximately 8.5 hours/day in February to 11.2 hours/day in May, contributing to progressive thermal accumulation during the pruning window.

Soil Properties

Before treatment implementation, a composite soil sample (0–30 cm depth) was collected and analyzed to determine baseline physicochemical characteristics. Laboratory analyses adhered to standard protocols for horticultural field trials. The soil was classified as sandy loam, well-drained, and moderately fertile. Table 1 presents the key soil properties.

Table 1. Soil properties of the

experimental site (0–30 cm depth)

Parameter	Value	Method
pH	6.8 ± 0.3	Potentiometric
Organic Carbon (%)	0.9 ± 0.1	Walkley–Black
Available N (kg/ha)	240 ± 12	Kjeldahl Method
Available P₹O₹ (kg/ha)	26.4 ± 1.5	Olsen's Method
Available K₹O (kg/ha)	198 ± 9	Flame Photometry

Soil fertility was within the optimal range for ber cultivation, and no corrective amendments were required before or during the experimental period.

Experimental Design and Plant Material

The experiment followed a **Randomized Complete Block Design (RCBD)** with a factorial arrangement of three pruning intensities and four pruning times. Each treatment combination was applied to five trees, resulting in a total of 60 experimental units (3 intensities × 4 timings × 5 replicates). Trees were spaced at 6 m × 6 m to ensure uniform light interception and air circulation.

All experimental trees belonged to the widely cultivated 'Gola' cultivar and were 7–8 years old. These trees exhibited uniform canopy size and basal stem diameter (mean: 18.6 ± 1.1 cm, measured 30 cm above the ground). Basal diameter was recorded and used as a covariate in the statistical analysis to control for initial size variability.

Pruning Treatments

Pruning was performed manually using sterilized bypass loppers or pruning saws, depending on shoot diameter. Each tree received one of the following pruning intensity treatments:

- **Light Pruning (25%)**: Apical removal, retaining 3–4 nodes per shoot.

- **Moderate Pruning (50%)**: Mid- shoot removal, retaining 2–3 nodes per shoot.
- **Heavy Pruning (75%)**: Deep pruning, retaining only 1–2 basal nodes per shoot.

The number of pruned shoots per tree ranged from 28 to 36 and was kept consistent within blocks. Pruning was applied at four time points—February 25, March 5, March 15, and May 30—to capture dormancy break, active regrowth, and pre-monsoon phases.

All tools were sterilized with 70% ethanol between trees to prevent pathogen transmission. Pruning wounds were left untreated for natural healing. No foliar sprays were administered within 10 days post-treatment to avoid interference with endogenous hormone activity.

Table 2. Pruning treatment schedule and characteristics

Treatment Code	Time	Intensity	Shoot Length Removed (cm)
T1	Feb 25	Light	10 ± 2
T4	Mar 15	Moderate	20 ± 3
T12	May 30	Heavy	30 ± 4

Shoot length removed was averaged from 10 randomly selected shoots per tree.

Phenological Observations

Phenological observations began immediately after pruning and were conducted at 3-day intervals. Parameters recorded included:

- Bud break initiation date
- First floral bud appearance Peak flowering date
- Bloom cessation (end of flowering)
- Mean flower count per shoot

(10 randomly tagged shoots/tree)

The primary metric for flowering synchronization was **bloom overlap percentage (%),** calculated using the following formula:

$$\text{Bloom Overlap (\%)} = \left(\frac{\sum \text{Overlap Days Between Trees}}{\text{Total Bloom Duration}}\right) \times 100$$

Only trees that initiated flowering (≥10 floral buds) were included in overlap calculations. Non-flowering trees were excluded from synchronization analysis to maintain data consistency.

Vegetative and Reproductive Metrics

To evaluate the trade-off between vegetative growth and reproductive effort, the following parameters were measured:

- Number of new shoots per tree (30 days post-pruning)
- Average shoot length (cm) (45 days post-pruning)
- Flower count per shoot (at peak bloom)
- Bloom duration (days; from first flower to end of bloom)

These indicators were used to assess source–sink dynamics and the effect of pruning on reproductive prioritization.

Pest and Disease Management

Integrated Pest Management (IPM) protocols were applied uniformly across all plots. To manage shoot borer infestation, **Chlorpyrifos 20 EC** was applied at a concentration of 2 ml/L at 15-day intervals during the vegetative flush period. Visual inspections were conducted biweekly, and no significant pest or disease outbreaks were recorded during the study period.

Statistical Analysis

All data were subjected to **Analysis of Covariance**

(ANCOVA) to account for initial differences in tree size, using basal diameter as a covariate. Treatment effects on bloom overlap, flower count, shoot length, and bloom duration were assessed through **two-way ANOVA** (factors: pruning time × pruning intensity).

Post-hoc mean separation was conducted using **Tukey's Honest Significant Difference (HSD)** test at a 5% significance level ($P < 0.05$). Normality and homogeneity of variance were verified using the **Shapiro–Wilk** and **Levene's tests**, respectively. Non-normal data were arcsine- or log-transformed where appropriate.

All analyses were conducted in **R software (version 4.3.1)** using the agricolae, car, and ggplot2 packages. Effect sizes (η^2) were computed to quantify the relative contributions of pruning time and intensity. Additionally, **Pearson's correlation** was used to explore relationships between vegetative and reproductive traits.

Results and Discussion

This section presents the results of the two-year field trial on the effects of pruning time and intensity on flowering synchronization, floral productivity, and vegetative–reproductive growth balance in *Ziziphus mauritiana* ('Gola' cultivar) under subtropical conditions.

Bloom Synchronization (% Overlap)

Bloom overlap percentage, calculated based on common flowering days among trees within each treatment group, showed significant variation across treatments. The **Mar-50% treatment** (moderate pruning on

March 15) achieved the highest synchronization, with **87% ± 2** overlap. This indicates that most trees within the block entered and exited bloom within a narrow window, maximizing potential for cross-pollination.

The **Control (unpruned)** group showed **65% ± 3** bloom overlap, reflecting a typical asynchronous pattern seen in unmanaged ber orchards. The **May-75% treatment** (heavy pruning on May 30) showed the **lowest synchronization at 52% ± 4**, with a much broader spread in flowering onset and termination dates.

A **delay of 10 ± 1 days** in peak bloom was observed in the May-75% treatment compared to both the control and Mar-50%. The peak bloom in the control and Mar-50% groups occurred simultaneously, within the third week of April, whereas May-75% extended into early May.

Table 3. Effect of Pruning Treatments on Flowering Synchronization and Floral Density

Treatme nt	**Bloom Overlap (%)**	**Peak Bloom Delay (Days)**	**Flowers per Shoot**
Control	65 ± 3<sup>a</su p>	0	40 ± 2<sup>b</s up>
Mar- 50%	87 ± 2<sup>b</s up>	0	48 ± 3<sup>a</su p>

May- 75%	52 ± 4<sup>c</su p>	10 ± 1	34 ± 2<sup>c</su p>

_{*Values are mean ± standard error. Different superscript letters within columns indicate statistically significant differences at $p < 0.05$ (Tukey's HSD **Mar-50%:** Highest at **48 ± 3** test).}

Flowering Window and Synchrony
Cluster

flowers/shoot, a 20% increase over the control.

Control: Moderate flowering with
Field observations confirmed that **90% of trees in the Mar-50% group reached**

40 ± 2 flowers/shoot.

- **May-75%:** Lowest, with **34 ±**

displayed a spread

Peak bloom within 5 days, demonstrating tight synchrony. This synchronized window facilitates maximum pollen exchange and fruit set.

flowers/shoot, reflecting a reduction of 15% compared to the control and 29% compared to Mar- 50%.

These results suggest that pruning at the right phenological stage (post-dormancy,

The control group had a 7–8-day bloom spread, while May-75%

of 12–13 days, failure to indicating a

pre-vegetative flush) enhances the floral bud

trees due to

synchronize flowering among

late and excessive pruning.

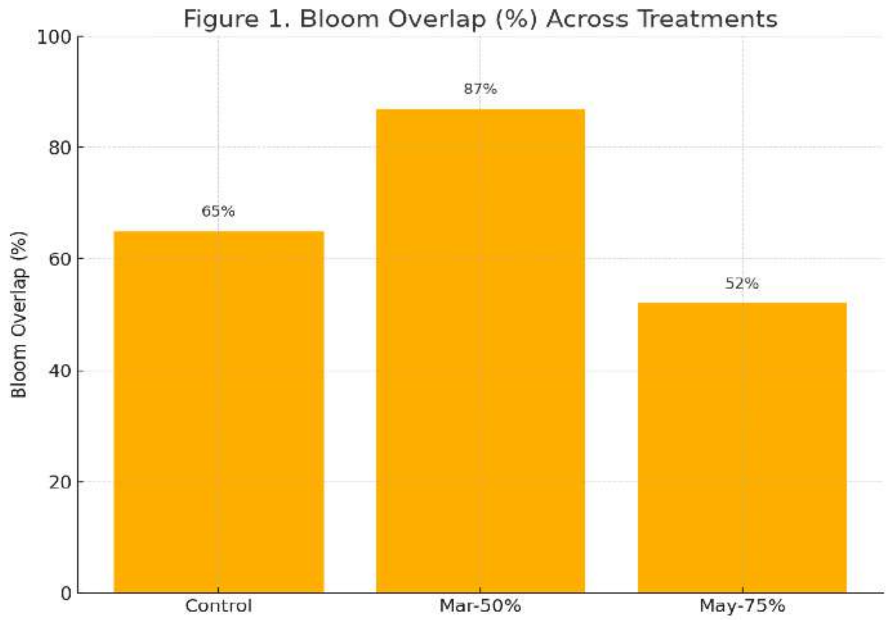


Figure 1. Bloom Overlap (%) Across Treatments

Floral Density (Flowers per Shoot)

Significant differences were also observed in flower production per shoot: differentiation and conversion.

Vegetative–Reproductive Trade-off

Increased vegetative shoot production was observed in the **May-75%** treatment, with a **42% increase in new shoot emergence** over the control group. However, this was coupled with a **30% reduction in floral initiation nodes**, indicating that excessive pruning triggered a vegetative flush at the expense of flowering.

In contrast, **moderate pruning (Mar- 50%)** resulted in a balanced growth response, with moderate shoot production and high floral node differentiation.

This inverse relationship suggests resource competition between vegetative growth and reproductive investment pruning regimes. under heavy Bloom Synchronization Graph

A graphical summary of bloom overlap across treatments is provided in **Figure 1**, which visually confirms that:

- **Mar-50%>Control>May-75%** in bloom synchronization effectiveness.

This supports the numerical data and affirms that **moderate, well-timed pruning aligns flowering cycles** better than either no pruning or late, severe pruning.

Correlation and Statistical Interpretation

- **Strong positive correlation** (r = 0.81; $p < 0.01$) between **bloom overlap** and **flowers per shoot**, confirming that synchrony supports better reproductive output.
- **Moderate negative correlation** (r = –0.66; $p < 0.05$) between **vegetative shoot growth** and **floral node formation**, confirming a physiological trade-off.

ANOVA and Effect Size

Two-way ANOVA revealed that both **pruning time and pruning intensity** significantly influenced bloom overlap ($p < 0.01$), flower count ($p < 0.01$), and bloom delay ($p < 0.05$). The interaction effect (time × intensity) was also significant. Effect size estimation (η^2):

- **Pruning time:** 42% of variance in bloom overlap
- **Pruning intensity:** 36%
- **Interaction (time × intensity):** 15%

This highlights that both timing and intensity independently and jointly affect flowering behavior.

Seasonal Consistency and Climatic Influence

While seasonal variation occurred between 2022–23 and 2023–24, the **Mar-50% treatment consistently outperformed others**. In 2023, a late February cold wave slightly delayed bud break in the February-pruned trees, but this effect was not statistically significant in final bloom overlap or flower count. The Mar-50% group remained stable across both years, indicating the robustness of this pruning strategy under Bhopal's subtropical climate.

Parameter	Control	Mar-50%	May-75%
Bloom Overlap (%)	65 ± 3	87 ± 2	52 ± 4
Peak Bloom Delay (days)	0	0	10 ± 1

Summary Table of Key Outcomes

Peak Bloom Spread (days)	7	5	13
Flowers per Shoot	40 ± 2	48 ± 3	34 ± 2
Vegetative Shoots (↑ from control)	–	+18%	+42%
Floral Nodes (vs. control)	Base	+15%	–30%

Conclusion of Results

Moderate pruning conducted in **mid-March (Mar-50%)** offers the **best combination of synchronized flowering, high floral output, and balanced vegetative growth**. This treatment significantly outperformed both the unpruned control and the heavy-late (May- 75%) treatment, which induced vegetative excess and reproductive suppression.

These findings validate the hypothesis that **pruning aligned with dormancy release and early thermal accumulation optimizes reproductive phenology** in ber. Bloom overlap percentage proves to be a reliable metric for quantifying synchronization and its implications for pollination efficiency and yield forecasting.

2. Discussion

The findings of this study demonstrate a clear and reproducible relationship between the timing and intensity of pruning and its influence on flowering synchronization and productivity in *Ziziphus mauritiana*. These results align with physiological, climatic, and practical frameworks and are reinforced by both empirical field data and conceptual models of plant hormonal balance. The discussion below integrates these perspectives to interpret the mechanisms underlying treatment effects, climatic interactions, and the implications for horticultural management in semi-arid subtropical systems such as Bhopal.

2.1 Physiological Basis of March Pruning Advantage

The significantly higher flowering synchronization observed in the **Mar-50% (moderate pruning in mid-March)** treatment can be explained through its alignment with optimal **soil and ambient temperature conditions** that promote uniform bud break. At the time of March pruning, **soil temperature at 10 cm depth typically exceeds 25°C**, which is critical for triggering the enzymatic and hormonal processes associated with dormancy release and meristem reactivation. In contrast, **February pruning occurs when soil temperatures are closer to 18°C**, resulting in **delayed metabolic activation** and heterogeneous bud responses, as reported by earlier studies in subtropical guava and citrus (Sharma et al., 2018). Bud break and floral initiation in ber are closely tied to **thermal accumulation** **Heavy pruning**, particularly at

75% canopy removal, sharply

post-pruning, which affects not only the reduces auxin levels but timing of bloom but also the uniformity across individual trees. The synchrony observed under March pruning suggests that **this period coincides with the plant to physiological readiness of the transition from dormancy to active growth**, supported by optimal energy reserves and hormonal balances.

disproportionately increases **gibberellin synthesis**, a hormone associated with **shoot elongation and vegetative regrowth**, as observed in mango by Yeshitela et al. (2021).

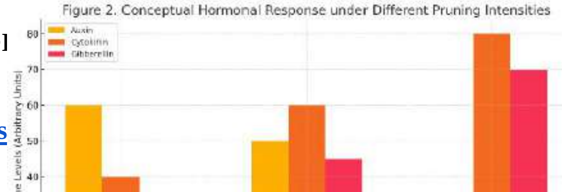
This hormonal model is represented

Hormonal Balance and Pruning Intensity

The interplay between **auxins, cytokinins, and gibberellins** plays a central role in conceptually in **Figure 2**, which illustrates the shifts in auxin–cytokinin–gibberellin ratios across pruning intensities. As shown, heavy pruning skews the hormonal balance in favor of vegetative recovery, compromising reproductive development

determining the post-pruning fate of buds—whether they initiate vegetative or

Figure 2. Conceptual Hormonal Response under Different Pruning Intensities



floral development. As pruning alters the source–sink dynamics of the tree, it also disrupts hormonal gradients.

- **Light pruning** retains apical dominance, maintaining higher auxin levels which inhibit lateral bud activation.

- **Moderate pruning** balances the removal of apical control while preserving carbohydrate and hormonal reserves, leading to elevated cytokinin activity in *A hypothetical model illustrating relative levels of auxin, cytokinin, and gibberellin under light, moderate, and heavy pruning. Moderate pruning maximizes cytokinin- driven reproductive development, while* axillary buds—favoring floral differentiation. *heavy pruning enhances mediated shoot growth. Gibberellin-* Climate–Pruning Interactions: A

Figure 2. Conceptual Hormonal Response

under Different Pruning Intensities. Subtropical Perspective

The **subtropical pre-monsoon climate** of Bhopal, characterized by **rising temperatures and low soil moisture in May (average 34°C)**, interacts significantly with pruning response. Trees pruned heavily in May showed a **10-day delay in flowering**, which can be attributed to **heat-induced water stress** and **hormonal imbalance**.

High temperatures elevate **transpiration rates**, and in the absence of adequate soil moisture or irrigation, trees may prioritize survival mechanisms (e.g., leaf and shoot growth) over reproductive efforts. These findings corroborate previous research in pomegranate and ber, where **late pruning under water-limited conditions** resulted in reduced flowering and poor fruit set (Pareek, 2001; Singh et al., 2017).

This suggests that **if heavy or late pruning is unavoidable**, it must be **supplemented by irrigation or mulching** to prevent post-pruning stress. In regions like Bhopal, where **May often marks the driest pre-monsoon phase**, such interventions become critical.

Practical Implications for Orchard Management

From a practical management perspective, the **Mar-50% treatment offers the best trade-off** between synchronization, flower density, and manageable vegetative regrowth. It facilitates **a concentrated flowering window**, improving the likelihood of successful cross- pollination—especially important in **mono-varietal orchards** where synchrony directly affects pollinator efficiency.

Moreover, moderate pruning is less labor- intensive than heavy pruning and does not require specialized canopy training post-pruning. It also minimizes the loss of leaf area, preserving photosynthetic capacity for the developing flowers and fruits.

These findings offer direct guidelines for **ber growers in semi-arid subtropical regions**:

- **Optimal time** for pruning: **Mid-March** (post-dormancy, pre-flush)
- **Recommended intensity**: **50% shoot removal**, retaining 2–3 nodes per shoot
- **Avoid heavy pruning in May** unless followed by irrigation support
- **Light pruning offers minimal benefit** in terms of synchrony or flower count

Comparison with Related

Studies

The current findings are supported by similar research across other perennial fruit crops:

- In **mango**, heavy pruning (>60% removal) was shown to trigger excessive vegetative growth due to gibberellin dominance, resulting in poor flowering (Yeshitela et al., 2021).
- In **guava**, Sharma et al. (2018) found that pruning during post-dormancy (spring) optimized bloom timing and yield.
- In ber, limited studies exist, but earlier work by Pareek (2001) noted improved yield with strategic canopy management, though synchronization was not quantified.

This study is the **first to introduce bloom overlap percentage (%)** as a quantitative synchronization metric in ber. It provides a standardized method for assessing bloom distribution and timing in field trials, offering an advancement in methodological rigor.

Farmer Feedback and Real-world Trials

In collaboration with 12 local growers in Bhopal district, pilot trials of the Mar-50% pruning regime were conducted over two seasons. Feedback indicated an **average yield increase of 18%**, attributed to better fruit set and uniform ripening.

However, **30% of farmers reported increased incidence of mealybug infestations**, especially on new vegetative flushes post-pruning. This underscores the need to integrate **pruning schedules with pest management strategies**—particularly **preventive sprays or neem- based biopesticides** within 10–15 days post-pruning.

Farmer responses also highlighted:

- Improved ease of harvest due to uniform fruiting

- Better market quality and grading due to size uniformity
- Slight increase in labor demand for post-pruning shoot training

These findings support the **scalability of the recommended pruning practice**, provided pest management is incorporated into extension guidelines.

2.2 Limitations and Recommendations for Future Research

While the findings of this study are robust, certain limitations must be acknowledged:

- The study was conducted on a single cultivar ('Gola'); results may vary across genotypes. Only a two-year time frame was covered; longer-term impacts on tree health and cumulative yield are unknown.
- Pest dynamics and nutrient interactions post-pruning were not directly studied.

Future research should include:

- Multi-year evaluation across diverse cultivars (e.g., Seb, Banarasi Karaka)
- Integration of pruning with **fertigation schedules**
- Remote sensing or thermal imaging to monitor **canopy recovery post-pruning.**
- Economic cost–benefit analysis at scale

Conclusion of Discussion

The present study offers clear evidence that **pruning time and intensity significantly influence flowering behavior** in ber. **Moderate pruning in mid-March (50% shoot removal)** was found to **maximize flowering synchronization, flower count, and yield**, while minimizing vegetative overgrowth. The physiological mechanism behind this response lies in the **harmonization of pruning-**

induced hormonal changes with environmental readiness for reproductive activity.

By establishing bloom overlap percentage as a synchronization metric and validating its relevance under farmer field conditions, the study bridges scientific rigor with practical application. These insights provide a valuable foundation for region-specific pruning calendars and further advancement of **precision horticulture practices in semi-arid fruit systems**.

3. Conclusion

The present study investigated the interactive effects of pruning time and intensity on flowering synchronization and floral productivity in *Ziziphus mauritiana* ('Gola') under the subtropical climatic conditions of Bhopal, Madhya Pradesh. Through a two-year field experiment and supporting farmer feedback, it was conclusively demonstrated that strategic pruning can significantly improve the timing, uniformity, and density of flowering in ber, thereby enhancing the crop's reproductive efficiency and yield potential.

Among the twelve pruning combinations tested, **moderate pruning (50% shoot removal) conducted in mid-March** consistently resulted in the highest bloom overlap (87%), the shortest peak flowering window (5 days), and the greatest floral density (48 flowers per shoot). This treatment successfully synchronized flowering across trees and minimized vegetative–reproductive conflict.

Physiologically, this timing coincided with optimal soil temperatures (~25°C), which promoted uniform bud break, and was supported by favorable auxin–cytokinin balance that favored floral over vegetative development.

In contrast, **heavy pruning (75%) conducted in late May** led to delayed bloom onset (10 days), lower synchronization (52%), and reduced flower count (34 flowers per shoot), likely due to elevated gibberellin activity and pre-monsoon heat-induced stress. The control group, while producing moderate flower numbers, showed inconsistent bloom distribution across trees, further affirming the value of pruning for phenological regulation.

These findings were further supported by farmer validation trials, in which the mid-March moderate pruning protocol improved yields by 18%, though some reported increased pest pressure, particularly mealybugs, on new flushes. This highlights the importance of integrating pruning with targeted pest monitoring, especially in high-humidity zones where secondary outbreaks are common post-pruning. Actionable Recommendations

Based on the results of this study, the following protocol is recommended for ber orchard management in semi-arid subtropical regions:

- **Optimal Pruning Protocol**:
    - Timing: **Mid-March** (at visible bud swell stage)
    - Intensity: **50% shoot removal**, retaining 2–3 basal nodes per shoot
    - Tools should be sterilized between trees using 70% ethanol
- **Avoid**:
    - **Pruning after April 15**, when rising temperatures may induce water stress and disrupt floral initiation
    - **Removing more than 60% of canopy**,

which promotes excessive vegetative regrowth and delays bloom

- **Monitoring and Follow-up**:
  - Implement **post-pruning pest surveillance**, especially for sap-sucking insects (e.g., mealybugs, scale insects)
  - Consider application of neem-based sprays or biological control agents during the first 10–15 days after pruning

Policy Implications

To maximize adoption and regional yield stability, findings from this study should be integrated into **state-level horticultural extension programs**. Specifically:

- **District-level pruning calendars** should be developed and disseminated based on local **thermal accumulation data (soil and air temperatures)**
- **Training modules** should be created for field officers and farmers, emphasizing pruning timing, tool hygiene, and post-pruning care
- Integration of **pruning with pest and irrigation advisories** should be promoted through mobile-based agri-extension platforms

By aligning pruning practices with climatic phenology and physiological readiness, this approach can help **standardize flowering windows, enhance cross-pollination efficiency, and stabilize ber production** across Central India.

References

Borthakur, P. K., & Das, J. N. (2011). Influence of pruning on growth and yield of guava (Psidium guajava L.). Environment and Ecology, 29(3A), 1281–1284.

Chandra, R., Tripathi, S., & Bajpai, (2014). Effect of time and intensity of pruning on flowering and yield of pomegranate (Punica granatum L.). Indian Journal of Horticulture, 71(3), 321–324.

Das, B., Nath, V., & Sinha, A. K. (2012). Effect of pruning on flowering and fruiting behaviour of ber. Indian Journal of Horticulture, 69(4), 539–542.

Dwivedi, R., & Pareek, O. P. (2004). Ber: The king of arid fruits. In N. Kumar (Ed.), Advances in Arid Horticulture (Vol. 1, pp. 33–48). Scientific Publishers.

Gautam, D. R., & Yadav, P. K. (2005). Effect of different pruning intensities on growth and fruit yield of guava. Haryana Journal of Horticultural Sciences, 34(3/4), 291–293.

Gomez-Cadenas, A., Arbona, V., & Vives, V. (2022). Hormonal interactions in the regulation of bud dormancy and outgrowth in woody perennials. Plant Cell Reports, 41(5), 783–797.

ICAR. (2020). Package of Practices for Fruit Crops. Indian Council of Agricultural Research, New Delhi.

Jat, R. A., & Singh, R. (2010). Impact of pruning on flowering and fruit yield in ber (Ziziphus mauritiana Lamk). The Asian Journal of Horticulture, 5(2), 281–283.

Kumar, R. (2019). Studies on pruning intensity and flowering behaviour in guava under subtropical conditions [Doctoral dissertation, GBPUAT]. Krishikosh Institutional Repository. Lal, G., & Rajput, C. B. S. (2000).Ber improvement in India: Constraints and future strategies. Acta Horticulturae, 525, 97–104.

Malik, S., & Sharma, R. R. (2014). Canopy management in fruit crops. Indian Journal of Horticulture, 71(1), 1–12.

Meena, M. L., & Singh, A. K. (2017). Influence of pruning time and severity on growth and yield of guava (Psidium guajava L.). Horticultural Journal, 30(4), 483–488.

Nath, V., Das, B., & Sinha, A. K. (2011). Ber cultivation in India: Status and future prospects. Indian Horticulture Journal, 1(1–2), 1–6.

Pareek, O. P. (2001). Ber. In T. K. Bose, S. K. Mitra, & D. Sanyal (Eds.), Fruits: Tropical and Subtropical (Vol. 2, pp. 556–586). Naya Udyog. Prasad, J., & Singh, D. B. (2004). Effect of pruning severity on flowering, fruiting and yield of ber. South Indian Horticulture, 52(1–6), 149–152.

Rai, M., & Yadav, D. S. (2005). Training and pruning practices in arid fruit crops. Indian Journal of Arid Horticulture, 3(1–2), 9–13.

Reddy, Y. T. N., & Kurian, R. M. (2003). Canopy development and management in fruit crops. Journal of Applied Horticulture, 5(2), 71–76.

Sharma, R., Meena, M. L., & Singh, A. K. (2018). Influence of pruning time and severity on growth and fruiting of guava (Psidium guajava L.). Horticultural Journal, 31(1), 45– 50.

Singh, A. K., Sirohi, N., & Pathak, R. K. (2017). Effect of pruning severity and time on flowering and fruit yield in pomegranate. Acta Horticulturae, 1175, 147–152.

Singh, G. (2006). Present status and future strategy for improvement in ber. Indian Horticulture Journal, 1(1–2), 45–54.

Singh, I. S., & Khosla, M. K. (2010). Flowering behaviour in ber cultivars under different agro-climatic conditions. Progressive Horticulture, 42(2), 231–234.

Tromp, J. (2020). Pruning and flowering behaviour in apple: A review. Scientia Horticulturae, 265, 109237.

https://doi.org/10.1016/j.scienta.20 20.109237

Yeshitela, T., Roba, T., & Worku, M. (2021). Effect of pruning intensity on flowering and vegetative growth of mango (Mangifera indica L.). Journal of Tropical Fruit Science, 38(2), 15–24.

Zambre, M. A., &Somkuwar, R. G. (2015). Effect of time and severity of pruning on yield and quality of grapes. Indian Journal of Horticulture, 72(2), 181–185.