"Bahar Treatment in Guava: A Key Strategy for Year-Round Fruit Production"

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ABSTRACT

Bahar treatment in guava is a crucial crop regulation strategy that ensures year-round fruit production by synchronizing flowering and fruiting cycles. This technique involves the strategic manipulation of irrigation, pruning, and nutrient management to induce flowering at desired times, allowing farmers to optimize yield and market availability. The principles of bahar treatment are rooted in understanding plant physiology and environmental factors, ensuring sustained productivity while maintaining fruit quality. Its significance lies in improving resource efficiency, stabilizing income for growers, and meeting consumer demand throughout the year. Economically, bahar treatment enhances profitability by reducing seasonal fluctuations and enabling better market positioning. However, challenges such as climate variability, labor-intensive practices, and the need for precise implementation can affect its effectiveness. Future advancements in biotechnology, automation, and precision agriculture may further refine this approach, making it more efficient and adaptable to changing agricultural conditions.

Keywords: Crop Regulation, Techniques, Chemical Interventions, Economical Effects, Impact and Challenges

1. INTRODUCTION

1.1 Guava's significance in horticulture

The genus Psidium (Myrtaceae) includes the guava (*Psidium guajava* L. 2n = 2x = 22), one of the most delicious and well-liked fruit crops, which is cultivated commercially across the tropics and subtropics (Pathak and Ojha, 1993; Rodríguez *et al.*, 2010; Mishra *et al.*, 2019). India leads the globe in guava production, with Pakistan, Mexico, Brazil, Egypt, Thailand, Columbia, and Indonesia following closely after (Pommer and Murkami, 2009). It is regarded as the "apple of the tropics" and is one of the most popular fruits in India, loved by both the wealthy and the underprivileged. It can survive a broad range of soil and climatic conditions, making it one of the most resilient fruit trees. Fruits of the guava plant are used either fresh or mostly processed into puree, paste, jam, jelly, nectar, syrup, ice cream, or juice. In support of its traditional uses, a number of studies have shown that guava has anti-inflammatory, anti-allergy, antimicrobial, antidiabetic, antigenotoxic, anti-plasmodial, cytotoxic, antispasmodic, cardioactive, anticough, anti-inflammat -ory, and antinociceptive properties (Gutierrez et al., 2008; Shruthi et al., 2013; Mishra *et al.*, 2022). Guava trees are resilient, extremely adaptable, and can grow in a variety of soil types, including marginal soils (Hussain *et al.*, 2020). Their fruit may be eaten fresh or turned into a variety of products, such as juices, jams, jellies, and more (Kanwal *et al.*, 2016). Because of its excellent nutritional content, accessibility, and reasonable prices, it has grown to be quite well-liked and available to customers. Triterpenoid acids, tannins, vitamins, sesquiterpene alcohols, and phenolic compounds, including essential oils, are among the noteworthy components of guava plants (Olatunde *et al.*, 2024). Compared to many other fruits, it is a rich source of vitamin C, with 150–200 milligrams per 100 g of pulp. Guava fruit is believed to control systolic blood pressure and contains antioxidant properties. With an average yield of 15.9 mt/ha, it is grown commercially in the sub-tropical areas of the Indian subcontinent, specifically in Uttar Pradesh, Punjab, and Haryana. The leading state in guava production is Uttar Pradesh (21.78%), followed by Madhya Pradesh (17.20%) and Bihar (9.62%). L-49 (Sardar), Arka Mridula, Allahabad Safeda, Pant Prabhat, Lalit, Khaja (Bengal Safeda), Dhareedar, Chittidar, and Harija are common guava cultivars in India. In addition, there are various hybrid types, such as Kohir Safeda, Arka Amulya, and Safed Jam. However, Uttar Pradesh produces the highest-quality guavas (Majeed *et al.*, 2024).

Table 1: Guava nutritional composition (Kajal Sahu *et al.*, 2025)

S.No.	Nutrients	Value/500gm
1.	Water	404gm
2.	Protein	12.75gm
3.	Carbohydrates	71.6gm
4.	Magnesium	110mg
5.	Calcium	90mg
6.	Fiber	27gm
7.	Phosphorus	200mg
8.	Energy	340 kcal
9.	Potassium	2085mg
10.	Vitamin C	1141.5mg
11.	Total fat	4.75gm
12.	Iron	1.3mg
13.	Vitamin B2 (riboflavin)	0.15-0.25mg
14.	Vitamin B3 (Niacin)	2.5-5.0mg
15.	Vitamin B6	0.5-1.0mg

1.2 Bahar Treatment: overview

When produced in India, guava is one of several tropical and sub-tropical fruit crops that, when left alone, produce a number of light harvests with varying numbers and characteristics from the year-round blooming flushes. According to (Mishra *et al.*, 2020), guavas naturally produce blossoms three times a year: in February and March (Ambe Bahar), June and July (Mrig Bahar), and October and November (Hasth Bahar) (Shukla *et al.*, 2008). The corresponding harvest occurs during the rainy, winter, and spring seasons, respectively. Understanding how crops bloom and bear fruit is essential, and after taking into account all relevant factors, bahar will yield a good harvest. Throughout the year, acid lime trees bloom continuously, with February and March marking a noticeable peak blooming time. On the other hand, July through August is a rather calm time of year. Guavas provide varying quantities of fruit throughout the year. In North India, the major crop typically ripens between July and mid-October, during the rainy season.

Table 2: Bahar (Blossom) in guava (Singh *et al.*, 2018)

Flowering season	**Flowering**	**Fruiting**
Ambe Bahar (February)	February – March	July –August
Mrig Bahar (June)	June- July	November- December
Hasta Bahar (October)	October- November	March – April (low yield)

2. CROP REGULATION

The pomegranate and guava plants are given a resting period during which the tree's natural propensity is artificially changed in order to increase fruit output during a specific time. It is accomplished by exposing the roots, depriving them of water for around 60 days before the typical flowering period, and using chemicals, commonly referred to as bahar therapy or flower management. A number of crops that bloom more than once a year don't consistently deliver fruit of high quality. Because of the relief from winter stress, guavas (Ambe bahar) produce more blossoms in the summer. As a result, it yields more fruit when it rains. The fruit maturity period is shortened to 30 days during this season due to high temperatures and rains, which results in surplus inventory on the market. In contrast, the winter crop, Mrig bahar, is of greater quality and commands a noticeably higher price. In contrast to the winter season, the rainy season guava produces more fruit (Rathore and Singh, 1974; Singh *et al.*, 2000), but the quality is worse because of its bland flavor and insect infestation (Rawal, 1988).

2.1 Principles of crop regulation

The fundamental idea of guava crop regulation, according to (Sathiah *et al.*, 2021), is to control the guava's flowering and fruiting behavior at the ideal time to maximize fruit quality yield, cost effectiveness, and environmental preservation by reducing the frequency of insecticide use. Crop regulation principles state that several elements, including identification, selection, implementat -ion, and controlling techniques, are employed to achieve higher quality and more cost- effective output. The most important sustainability fact is that there must be negative consequences for the environment or the bottom line in order to implement this idea. (Kumar *et al.*, 2021).

2.2 Significance of crop regulation

Crop management is meant to make the tree relax and provide an abundance of fruits and flowers. Holing irrigation water, root exposure, root and shoot trimming, deblossming, chemical spraying, and other plant growth regulators can all help achieve this. A number of crops that bloom more than once a year don't consistently deliver fruit of high quality. Because of the relief from winter stress, guavas (Ambe bahar) produce more blossoms in the summer. As a result, it yields more fruit when it rains. The fruit maturity period is shortened to 30 days during this season due to high temperatures and rains, which results in surplus inventory on the market. In contrast, the winter season crop, Mrig bahar, is of superior quality and commands a noticeably higher price. In contrast to the winter season, the rainy season guava produces more fruit (Rathore and Singh, 1974; Singh *et al.*, 2000), but the quality is worse because of its bland flavor and insect infestation (Rawal, 1988). By lowering the frequency of pesticide use, the basic idea of crop regulation is to control the guava plant's natural flowering and fruiting during the preferred season of the year, which enhances the overall fruit yield, quality, profitability, and property of the surrounding area (Mahadevan, 2014).

3. TECHNIQUES FOR CROP REGULATION IN GUAVA FRUIT

Guavas typically bloom twice a year, in March and April (Ambe bahar) and June and July (Mrig bahar), with the fruits ripening in the winter and rainy seasons, respectively. Nonetheless, a third crop with flowers that grows in central and southern India. March is when the fruits of October (Hastha bahar) mature. This blossoming pattern and economic exploitation of fruiting is undesirable (Mishra *et al.*, 2020). Furthermore, the majority of guava producers suffer a large loss as a result of the insipid, watery, low-quality, and fruit fly-infested Ambe bahar fruits that are harvested between July and September (Thakre *et al.*, 2016). The fruits of the winter season are of higher quality, pest-free, and have great market value (Singh *et al.*, 2000). It goes without saying that crop control, which provides different flower and fruit thinning treatments over the summer, would greatly aid in resolving such issues. There are several methods to prevent monsoon crops, such as manual deblossoming and the use of pesticides during the blossoming and pre-bloom stages, which hence promote healthy crops, as previously published studies.

3.1 Shoot pruning

Since guava blooms are always produced on recently emerged vegetative shoots, shoot trimming has been shown to be very effective in guava regardless of the season (Thakre *et al.*, 2016). Guava is special because it can be trimmed to control the production (Lotter, 1990). Reducing tree size and enhancing fruit quality are two benefits of shoot trimming (Singh and Bal, 2006). Numerous researchers (Bajpai *et al.*, 1973; Lal, 1983; Jadhav *et al.*, 1998; Lal *et al.*, 2000; Singh and Singh, 2001; Dhaliwal and Singh, 2004) have documented the positive impact of pruning on guava productivity and fruit quality. (Salah, 2005) found that guava trees with severe and moderate trimming had the maximum bud emergence. Guava cv. Paluma tree sprout and yield were impacted by the timing and severity of pruning (Serrano *et al.*, 2008a). Additionally, it was noted that in guava cv. Paluma, mild pruning enhanced the amount of fruit per branch and the number of productive branches (Serrano *et al.*, 2008b). Similarly, the best way to decrease production during the rainy season and increase yield and quality throughout the winter in Nepal was to prune guava trees at a 20 cm pruning level in early May (Adhikari and Kandel, 2015). The best way to increase the yield of monsoon flushed crops and the quality of the fruit of spring and monsoon flushed crops in guava was to moderately prune the bearing shoot of the current season's growth right before bud opening in the summer. The reason for this might be that the plants stored food throughout the rainy season, which they could have used to produce winter fruits (Chandra and Govind, 1995). In May and June, pruning causes more photosynthetic photon flux to enter the canopies of trimmed trees than in unpruned trees. This greatly boosted the amount of fruit that could be harvested in December and January. Thus, it can be said that it is economically efficient to shift rainy season crops to the winter months in guava cultivars with May pruning (Singh *et al.*, 2001).

3.2 Shoot bending method

The training of guava branches is crucial to this procedure. In order to produce fruits during the off-season, guava plants' branches are bent down 45–60 days before to the anticipated blooming date based on the estimate of projected flowering. Given that guava trees with upright shoots bear poorly, a variety's growth habit may influence its yield and quality (Singh, 1995). Bending practices assist control blooming (Srivastava *et al.*, 2022) and provide profuse flowering that commands a fair price (Nanda *et al.*, 2023). When shoot bending treatment was used during the on-season (312.33), (Kumar *et al.*, 2021) produced more blooms per plant, however during the off-season (111.33), it decreased blooming. When the guava plant is two years old, it is best to bend its branches for the first time. Small shoots, blooms, and fruits are cut off or removed from the branch before the leaves are bent, leaving 10–12 inches of terminal twigs in place. It takes 20–25 days for the new shootlets to appear during the fall season (September–November). When the young shootlets are around 1 cm long, bent branches should be loosened. Following 45–50 days of summer and 60–65 days of autumn bending, the new shootlets begin to flower at the 4-5 pairs of leaf stage. Applying fertilizer and manures 15 days before to branch bending and again during the pea stage of fruit development, after watering, is recommended.

3.3 Root pruning and root exposure

This technique removes the top soil (7–10 cm) within a 40–60 cm radius of the tree trunk, exposing the roots to the sun. This lowers the amount of moisture reaching the top, causing the leaves to start dropping and the tree to enter a rest period. In light sandy and shallow soils, root exposure is not necessary since withholding irrigation water for two to three weeks is enough to cause leaf withering and shedding. After around three to four weeks, the exposed roots are once more covered with a mixture of soil and manure, and then they are watered (Singh, 1995; Lal *et al.*, 2017). In order to reduce the rainy season crop and get a healthy winter crop, water stress can be created by exposing the roots and pruning small roots (Cheema *et al.*, 1954). However, in Uttar Pradesh, this root pruning technique is not advised or used as it causes moisture stress, which eventually leads to leaf drop and tree development termination during the undesired bahar period (Kumar *et al.*, 2021).

3.4 Deblossoming technique

In a study, (Ikhlaq *et al.*, 2022) also observed significant de-blooming in the summer guava crop. In the cv. Sardar Guava, deblossoming the rainy guava crop with an application of NAA at 800 ppm would contribute to a higher winter crop production (Mishra and Singh 2021). With differing degrees of effectiveness, flower thinning has been attempted with naphthalene acetic acid (NAA), naphthalene acetamide (NAD), 2,4-dichlorophenoxy acetic acid (2,4-D), potassium iodide (KI), 2-chloroethyl phosphonic acid (ethephon), 4,6-dinitro-ocresol (DNOC), and urea. Cultivars, tree health, soil composition, and environment might all contribute to this difference. Guava flowering may be eliminated with the use of a number of pesticides, which enhances the remaining yield

(Kumar *et al.,* 2021). On a small scale, in a kitchen garden, and while the plant is young, manual deblossoming of rainy season flowers works quite well. However, on big commercial plantations, it is difficult to follow and is exceedingly time-consuming, expensive, and burdensome. (Sahay and Kumar, 2004) state that Sardar guava may be utilized for winter cropping by manually deblossoming and trimming the third and fourth current shoots on May 30 after a double spray of 15% urea at 50% bloom stage and 10 days after the first spray. Guava has shown the greatest deblossoming when sprayed with 20% urea (Singh et al., 1996). However, (Choudhary et al., 1997) discovered that the most efficient way to deblossom the rainy season guava crop was to use 15% urea. (Maji et al., 2015) found that in order to obtain higher quality fruits of the guava cv. L-49 (Sardar) and more profitable winter season output, summer deblossoming with NAD @ 60 ppm may be the most effective crop regulating treatment, followed by NAA @ 500 ppm and NAD @ 40 ppm.

3.5 Holding back of irrigation water

According to this method, trees are not watered from February to mid-May, which causes them to lose their blossoms and go into a rest phase where food resources accumulate in the branches (Singh, 1995; Sachin *et al.,* 2015). This approach works well for light sandy soils, however it was not shown to be helpful in heavy soils or Tarai area soils (Tiwari and Lal, 2000). However, it is advised to prune the roots and restrict water in December or January for heavy soils. If irrigation is stopped on the northern plains after the winter crop is harvested, the tree will rest and its blooms will fall. In June, the tree basin is excavated, fertilized, and watered. The tree began to blossom profusely after 20 to 25 days, and its winter fruit matured. Melrose and (Normandeau, 2021) added that on the Indian plains, irrigation is stopped after harvest in April or May in order to achieve crop management. This habit causes the plant to fall into dormancy and shed its leaves and blooms. Irrigation is resumed in June, which leads to abundant flowering one month later and the maturation of the fruits over the winter.

3.6 Nutrition

The fertilizer schedule should be adjusted from April to May to May to June in order to improve the quantity of winter crops. This will encourage greater vegetative development, which will raise the amount of winter cropping. According to (Kowalska *et al.,* 2023), the optimal time to apply fertilizer is in June, July, and August since it promotes growth and blooming for a better winter production. Guava crop output will increase if the fertilizer schedule is changed from April to May to June during the winter months. This is because more vegetative growth will occur. Additionally, (Kumar *et al.,* 2021) recommended applying different fertilizers and manures 15 days before to branch bending (if encountered), then again at the pea stage of fruit growth, and finally, watering. In order to induce higher vegetative development, (Gupta and Nijjar, 1978) recommended applying a mixture of NPK@ 40, 100, and 40 g, respectively. The fertilizer schedule should be adjusted from April to May to May to June in order to boost the quantity of winter crops. This will cause greater vegetative growth, which in turn raises the winter cropping.

3.7 Chemical Intervention for Crop Regulation

A key tactic for producing a high-quality and high-quantity harvest is the use of chemicals to regulate crop load during the rainy season (Singh *et al.,* 2002). It has been discovered that growth regulators are very effective in regulating floral thinning and the cropping season. A straightforward method of crop control is chemical spraying. Rainy-season crops were deblossomed by some chemicals, which resulted in an improvement in winter crops. According to (Singh *et al.,* 2002), guava crop management has been shown to be cost-effective for quality invention with a single 25% urea spray and two 10% urea sprays in Sardar and Allahabad Safeda, respectively, during the bloom stage (April–May). The fruit quality was greater and the treatments had no detrimental effects on the tree since the fruiting was mostly focused in the winter. Allahabad safeda that are 10 years of age or older According to (Dubey *et al.*, 2002), induced the most defoliation during the rainy season blooming and produced the most fruit in the winter, both in terms of production and quality. Similar results were obtained by (Choudhary *et al.,* 1997) and (Das *et al.,* 2007). A spraying of 60 parts per million of NAA produced the highest fruit weight, yield, and ascorbic acid in the winter crop of a 15-year-old guava tree cultivar called Sardar, according to (Yadav *et al.,* 2001). Fruit volume (185.38 ml), pulp thickness, weight (175.57 g), pulp percentage (96.66), and canopy spread all increased in tandem, according to (Agnihotri *et al.*, 2013).

3.8 Modern techniques of crop regulation

Precision agriculture and genetic engineering have significantly improved guava cultivation by enhancing crop management and plant traits. The use of sensor technology in precision agriculture enables farmers to monitor environmental variables and apply fertilizers and water more precisely, leading to better flowering and fruiting stages. Additionally, genetic engineering has resulted in disease-resistant guava varieties with enhanced floral and fruiting characteristics, further boosting yield and quality. Together, these advancements contribute to more efficient and productive guava farming (Huang *et al.,* 2021; Shaikh *et al.,* 2022).

4. EVALUATING THE ECONOMIC EFFECTS OF CROP REGULATION ON PRODUCTION AT THE FARM LEVEL

In India, consumers and marketers are becoming more interested in high-quality guava fruits. Sardar and Allahabad Safeda, the two most popular guava varieties cultivated in India, produce naturally poor-quality fruits during the wet season (Singh *et al.*, 2002). According to (Singh *et al.*, 2000), applying 10% urea spraying in the winter significantly raised the yield (100 kg/tree) in "Allahabad Safeda." Summer deblossoming with a NAD@ 60 ppm spray yielded the greatest benefit:cost ratio (7.84:1), according to Maji et al. (2015). According to (Thakre, 2016), lone leaf pair pruning of fruited branches alone (OLPF) occurs in guava cultivars. With a cost-benefit ratio of 1:2.96, Pant Prabhat turned out to be more profitable than other therapies. Furthermore, the best results from this treatment were obtained during the winter and rainy seasons.

5. IMPACT OF CROP BAHAR TREATMENT ON GUAVA FRUIT QUALITY

Impact on Nutritional Content: Guava fruits that are high in nutrients might result from good soil management and water management. The health advantages of the fruit are attributed to the enhancement of vitamins, minerals, and antioxidant levels through the use of biotechnological techniques, organic and inorganic fertilizers, and environmental stress management (Jiménez-Gómez *et al.,* 2017).

Impact on Productivity and Yield: Guava fruit quality and yield are impacted by crop regulation techniques. Increasing output requires effective use of fertilizer, water, and pruning (Suman and Bhatnagar, 2019). To ensure constant output and quality, it is essential to balance quality and quantity, use current techniques, and take sustainability and economic factors into account (Muhie, 2022).

Effects on Physical Appearance: Crop management techniques have a major impact on the size, shape, color, and texture of guava fruit. Frequent trimming gives the tree shape and produces consistent fruit sizes (Yahia *et al.*, 2011). A pleasing color, texture, and overall beautiful look are guaranteed by proper nutrient and water management as well as efficient insect control (Fitri *et al.*, 2022).

6. CHALLENGES AND FUTURE PERSPECTIVES IN GUAVA CROP REGULATION

Commercial guava has embraced cultural and hormonal modifications for fruit setting and bloom induction for a number of reasons. These are meant to control consistent, high-quality fruits (Lal *et al.*, 2017). The harvesting season can be prolonged (Mishra *et al.*, 2018), diseases and insect pests can be lessened (Khan *et al.*, 2011; Lal *et al.*, 2017), and environmental sustainability, profitability, and nutritional quality can all be improved (Singh *et al.*, 2000; Das *et al.*, 2007; Maji *et al.*, 2015; Lal *et al.*, 2017). Guava fruit growing faces with difficulties. Despite improvements in agricultural technology, farmers still face challenges managing diseases and pests. Significant productivity and fruit quality losses can result from illnesses and insects (Kondoyanni *et al.*, 2022). Since improper methods can result in toxicities or shortages, managing water and nutrients also poses significant issues (Dowd *et al.*, 2008).The unpredictability of climate change's effects adds still another level of complexity, influencing yield and quality (Lipiec *et al.*, 2013). Effective cultivation is hampered in some areas by a lack of trained workers and cutting-edge technology (Kabir *et al.*, 2018), and guava farming may become financially hazardous due to changes in global markets (Rana, 2021). There are plenty of chances for study and development in spite of these obstacles. Sustainable output can be enhanced by creative, eco-friendly pest and disease management techniques (Pouthika, 2023). There are revolutionary opportunities for managing water and nutrients with the use of smart farming and precision agriculture (Javaid *et al.*, 2022). More resistant guava types might potentially be produced through selective breeding and genetic engineering. Furthermore, guava farming may become more profitable by emphasizing fair trade methods and bolstering regional economies (Telwala, 2023).

Future Trends and Innovations: With a number of new developments and trends, the guava industry appears to have a bright future. The cultivation process might become more efficient by the automation of several tasks through the integration of robots and artificial intelligence (AI) (Balaska *et al.*, 2023).To lessen the impact of global warming on guava farming, climate-resilient methods will be crucial. Resource usage may be maximized through a circular economy strategy that reduces waste. Guava farming throughout the world may also benefit from international cooperation and information and technology transfer (Khan *et al.*, 2020).

7. CONCLUSION

Because guavas naturally blossom three times a year—in February–March, June–July, and October–November—and are harvested in the rainy, winter, and spring seasons, respectively, potential production is not realized during the intended time frame. Therefore, bearing guava trees are artificially given a resting interval to change the plants' natural blooming inclination in order to increase fruit output during a certain time. Several cultural and chemical techniques can be used to successfully implement crop management in guava. Numerous investigations conducted by researchers have strongly supported the idea that using a variety of cultural and chemical techniques can effectively control summer blooming and yield winter fruits. According to the results of many guava experiments published by experts, winter fruits were noticeably better in every way. Different strategies are used for regulation. The prudent use and accessibility of chemicals, as well as labor, expertise, and knowledge, are essential for the successful implementation of guava crop regulation. The fundamental idea behind crop control is to encourage blooming and fruiting at the desired season of the year, which increases fruit output, quality, profitability, and environmental sustainability by minimizing the frequency of pesticide usage. Research on crop management revealed that the deblossoming of summer flowers and the production of winter fruits in guava may be controlled by shoot trimming and the administration of different chemicals. However, there are still issues with finding the ideal balance between quality and production, ethical issues with genetic engineering, and the requirement for international regulatory compliance. In order to advance guava farming into a sustainable future, it is imperative that farmers, academics, and policymakers collaborate, conduct ongoing study, and use cutting-edge technology.

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