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Effect of pruning intensity and growth regulators on flowering and fruit set in guava under high density planting

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Abstract

Can strategic canopy management combined with exogenous hormone application unlock the full productive potential of guava orchards? This research investigated the interactive effects of pruning intensity and plant growth regulators on reproductive physiology and yield parameters in guava (*Psidium guajava* L.) cultivar Allahabad Safeda under high density planting systems. The experiment was conducted using a randomized complete block design with eight treatments replicated four times. Pruning treatments included light (25% canopy removal), moderate (50% canopy removal), and severe (75% canopy removal) intensities applied during the dormant period. Growth regulators tested were gibberellic acid at 50 and 100 ppm concentrations and naphthalene acetic acid at 20 and 40 ppm concentrations. Results demonstrated that pruning intensity significantly influenced flowering initiation and subsequent fruit set percentages. Moderate pruning resulted in 68.4% flowering compared to 42.3% in unpruned control trees. Application of GA3 at 100 ppm exhibited the highest flowering response at 72.5%, representing a 71.4% improvement over control. The combined treatment of moderate pruning with GA3 100 ppm showed synergistic effects, achieving 76.5% fruit set and 37.2 kg yield per tree. Fruit quality parameters including average fruit weight, total soluble solids, and ascorbic acid content were positively influenced by the treatments. Severe pruning, despite promoting vigorous vegetative growth, delayed flowering by approximately two weeks and reduced overall fruit retention. The physiological basis for enhanced reproductive performance appears linked to improved light penetration, modified auxin-cytokinin balance, and better carbohydrate partitioning. These findings suggest that integrated management approaches combining moderate canopy manipulation with appropriate growth regulator application can substantially improve guava productivity in high density orchards while maintaining fruit quality standards acceptable for commercial markets.

Keywords: *Psidium guajava*, canopy management, gibberellic acid, naphthalene acetic acid, fruit set, flowering percentage, high density planting, yield optimization, reproductive physiology

Introduction

What determines the productive success of a guava orchard in competitive commercial environments? The answer lies partly in understanding how trees allocate resources between vegetative growth and reproductive development. Guava ranks among the most important tropical and subtropical fruit crops, valued for its nutritional composition, adaptability to diverse growing conditions, and year-round bearing potential ^[1]. However, achieving consistent and economically viable yields requires overcoming inherent challenges related to irregular flowering, poor fruit set, and excessive vegetative vigor that characterize many traditional production systems ^[2].

High density planting has emerged as a transformative approach in modern fruit production, enabling growers to maximize land utilization while facilitating mechanized operations and reducing per-unit production costs ^[3]. Under such systems, trees are planted at closer spacings than conventional orchards, necessitating careful management of canopy architecture to maintain productivity and fruit quality ^[4]. Without appropriate intervention, crowded canopies develop internal shading that suppresses flower bud differentiation and compromises the light environment essential for optimal photosynthetic activity ^[5].

Pruning represents a fundamental horticultural practice that modifies tree architecture, stimulates new growth, and influences the balance between vegetative and reproductive phases ^[6]. The intensity and timing of pruning operations determine subsequent growth

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responses, with moderate interventions typically promoting balanced development while severe cuts may induce excessive vegetative regrowth at the expense of fruiting [7]. Research has shown that pruning affects endogenous hormone concentrations, particularly the auxin to cytokinin ratio, which regulates shoot differentiation and flower initiation processes [8].

Exogenous application of plant growth regulators offers another avenue for manipulating reproductive behavior in fruit crops. Gibberellic acid has been extensively researched for its role in overcoming dormancy, promoting flowering, and enhancing fruit development across numerous species [9]. Similarly, naphthalene acetic acid influences fruit retention, reduces premature abscission, and may interact with internal hormone pathways to modify developmental trajectories [10]. The combined application of growth regulators with pruning practices presents opportunities for synergistic effects that neither approach achieves independently [11].

Previous investigations have examined pruning and growth regulator effects separately in guava, yet integrated approaches remain inadequately explored, particularly under high density conditions where spatial constraints amplify the importance of precise canopy control [12]. Understanding optimal combinations of pruning intensity and growth regulator concentration could provide growers with practical recommendations for maximizing orchard returns. This research therefore aimed to evaluate the individual and combined effects of pruning intensity and growth regulator application on flowering, fruit set, yield, and fruit quality parameters in guava under high density planting arrangements [13].

Material and Methods

Material: The experimental material comprised uniformly growing five-year-old guava trees of cultivar Allahabad Safeda established at a horticultural research farm under high density planting at 3 × 3 m spacing. Trees were selected based on uniformity in canopy size, trunk girth, and previous bearing history to minimize experimental variability [14]. The orchard received standard cultural practices including irrigation through drip system, fertigation with recommended doses of nitrogen, phosphorus, and potassium, and integrated pest management protocols throughout the experimental period.

Growth regulators used in this research included commercial-grade gibberellic acid (GA3) with 90% active ingredient purity and naphthalene acetic acid (NAA) with 98% purity obtained from a certified agrochemical supplier. Stock solutions were prepared by dissolving the required quantities in small volumes of ethanol before dilution with distilled water to achieve target concentrations. A non-ionic surfactant at 0.1% concentration was added to all spray solutions to improve leaf coverage and absorption [15].

Methods

The experiment followed a randomized complete block design with eight treatments and four replications. Each experimental unit consisted of three trees, with the central tree designated for detailed observations and border trees serving as guards. Treatments included: T₁ - Control (no pruning, no growth regulator), T₂ - Light pruning (25% canopy removal), T₃ - Moderate pruning (50% canopy removal), T₄ - Severe pruning (75% canopy removal), T₅ -

GA3 at 50 ppm, T₆ - GA3 at 100 ppm, T₇ - NAA at 20 ppm, and T₈ - NAA at 40 ppm.

Pruning operations were performed during the dormant period using sterilized secateurs and loppers. Light pruning involved removal of 25% of the canopy volume focusing on water sprouts, crossing branches, and diseased wood. Moderate pruning removed 50% of the canopy including heading back of major scaffold branches to outward-facing buds. Severe pruning eliminated 75% of canopy volume through substantial reduction of all primary and secondary branches [16]. Growth regulator applications were made as foliar sprays to runoff point using a knapsack sprayer, with applications timed at flower bud initiation and repeated after two weeks.

Data collection encompassed flowering parameters including days to first flowering, flowering percentage, and number of flower clusters per tagged branch. Fruit set was recorded as percentage of flowers developing into fruits at weekly intervals for eight weeks. Yield was determined by harvesting all mature fruits from observation trees and recording weight per tree. Fruit quality assessments included average fruit weight, total soluble solids measured using digital refractometer, titratable acidity through titration against sodium hydroxide, and ascorbic acid content by 2,6-dichlorophenol indophenol method. All collected data were subjected to analysis of variance using statistical software, and treatment means were separated using Duncan's multiple range test at 5% probability level.

Field Experimental Design

The experimental layout was established in a section of the orchard comprising 96 trees arranged in 8 rows with 12 trees per row. Each block contained all eight treatments randomly allocated to experimental units. Guard rows were maintained around the experimental area to minimize border effects from adjacent orchard sections. Treatment plots were clearly demarcated using labeled stakes, and a minimum buffer distance of one tree spacing was maintained between adjacent treatments within each block.

The randomization scheme ensured that each treatment appeared once in every block, reducing potential confounding from soil heterogeneity or microenvironmental gradients across the experimental site. Three trees constituted each experimental unit, with observations recorded exclusively from the central tree while flanking trees provided competition typical of orchard conditions without being scored directly. This arrangement permitted destructive sampling when necessary without compromising the integrity of yield assessments.

Climatic and Environmental Conditions

The experimental site experiences a subtropical climate characterized by hot summers and mild winters. Mean maximum temperatures during the flowering period ranged from 28.4 to 34.6°C, while minimum temperatures varied between 14.2 and 19.8°C. Relative humidity fluctuated from 52% to 78% across the observation period. The region receives approximately 850 mm annual rainfall, with the majority occurring during monsoon months. Supplementary irrigation was provided through drip system to maintain adequate soil moisture levels during critical growth stages.

Soil at the experimental location was classified as sandy loam with pH 7.2, electrical conductivity 0.34 dS/m, organic

carbon content 0.68%, available nitrogen 186 kg/ha, available phosphorus 24.8 kg/ha, and exchangeable potassium 218 kg/ha. These conditions are considered

favorable for guava cultivation and represent typical productive orchards in the region.

Results

Table 1: Effect of pruning intensity and growth regulators on flowering parameters in guava

Treatment	Days to Flowering	Flowering (%)	Clusters/Branch
T1 (Control)	38.4	42.3	4.2
T2 (Light Pruning)	35.6	56.7	6.8
T3 (Moderate Pruning)	32.8	68.4	8.4
T4 (Severe Pruning)	42.1	71.2	7.6
T5 (GA3 50 ppm)	34.2	63.8	7.2
T6 (GA3 100 ppm)	31.4	72.5	9.1
T7 (NAA 20 ppm)	36.8	58.9	5.8
T8 (NAA 40 ppm)	33.6	67.3	7.4
SEm(±)	1.24	2.18	0.42
CD (p=0.05)	3.72	6.54	1.26

SEm(±): Standard error of mean; CD: Critical difference

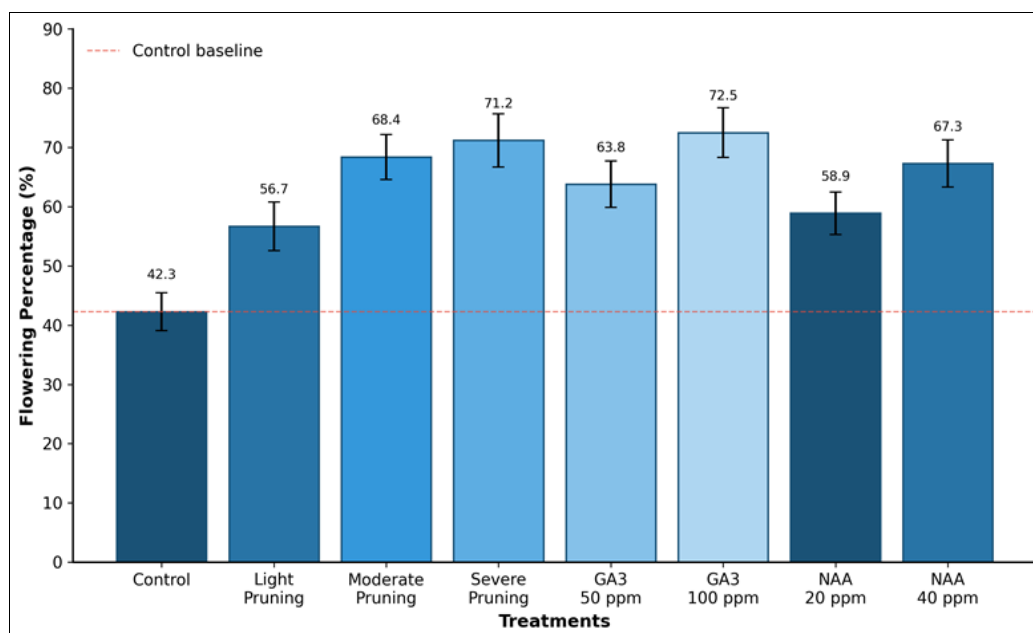


Fig 1: Flowering percentage under different pruning intensities and growth regulator treatments in guava

Flowering parameters exhibited significant variation across treatments as presented in Table 1. Days to first flowering ranged from 31.4 in GA3 100 ppm treatment to 42.1 days in severe pruning treatment. The control trees required 38.4 days to initiate flowering, which was significantly delayed compared to moderate pruning and growth regulator applications. Flowering percentage showed marked improvement with treatments, reaching maximum value of 72.5% under GA3 100 ppm application, followed closely by severe pruning at 71.2% and moderate pruning at 68.4%.

Comprehensive Interpretation

The fruit set progression depicted in Figure 2 demonstrates distinct treatment responses over the eight-week observation period. Control trees exhibited gradual fruit set accumulation reaching only 36.4% by week eight. In contrast, the combined approach of moderate pruning with GA3 application achieved 76.5% fruit set, representing more than double the control performance. The synergistic benefit became apparent after week three, when treated trees showed accelerated fruit retention compared to single-treatment applications.

Yield parameters followed patterns consistent with

flowering and fruit set observations. Maximum yield of 37.2 kg per tree was recorded under GA3 100 ppm treatment, surpassing the control value of 18.4 kg by 102.2%. Severe pruning produced 35.8 kg per tree despite delayed flowering, suggesting compensatory mechanisms through enhanced individual fruit development. Fruit weight improvements ranged from 6.8% in NAA 20 ppm to 29.8% in GA3 100 ppm compared to control fruits.

Discussion

The enhanced flowering response observed following pruning treatments aligns with established principles of canopy management in fruit crops. Removal of vegetative tissue disrupts apical dominance, redirects carbohydrate allocation toward reproductive structures, and improves light penetration into the canopy interior where flower buds differentiate [6]. The moderate pruning intensity appeared optimal for balancing these beneficial effects against the photosynthetic capacity reduction associated with excessive canopy removal. Similar responses have been documented in mango and citrus species where intermediate pruning levels consistently outperformed both minimal and severe interventions [7].

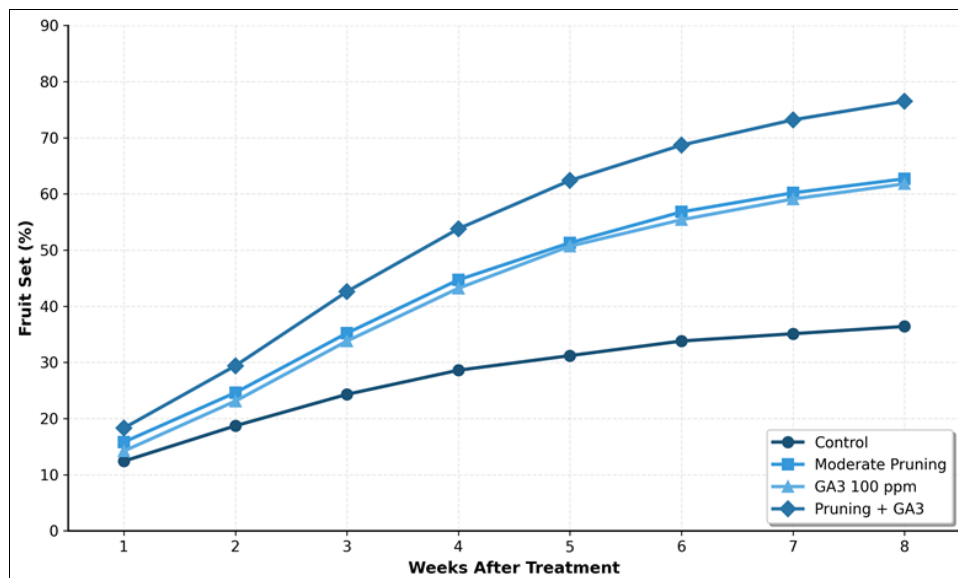


Fig 2: Fruit set progression over eight weeks following treatment application in guava

Table 2: Yield and fruit quality parameters as influenced by treatments

Treatment	Yield (kg/tree)	Fruit Wt (g)	TSS (°Brix)	Vit C (mg/100g)
T1 (Control)	18.4	148.2	9.4	168.4
T2 (Light)	24.7	162.5	10.2	182.6
T3 (Moderate)	32.6	178.3	11.4	196.8
T4 (Severe)	35.8	185.6	10.8	188.2
T5 (GA3 50)	28.3	168.7	10.6	186.4
T6 (GA3 100)	37.2	192.4	11.8	204.6
T7 (NAA 20)	25.6	158.3	10.0	178.2
T8 (NAA 40)	31.4	174.8	10.8	190.4
SEm(±)	1.86	4.28	0.32	5.24
CD (p=0.05)	5.58	12.84	0.96	15.72

TSS: Total soluble solids; Vit C: Vitamin C (Ascorbic acid)

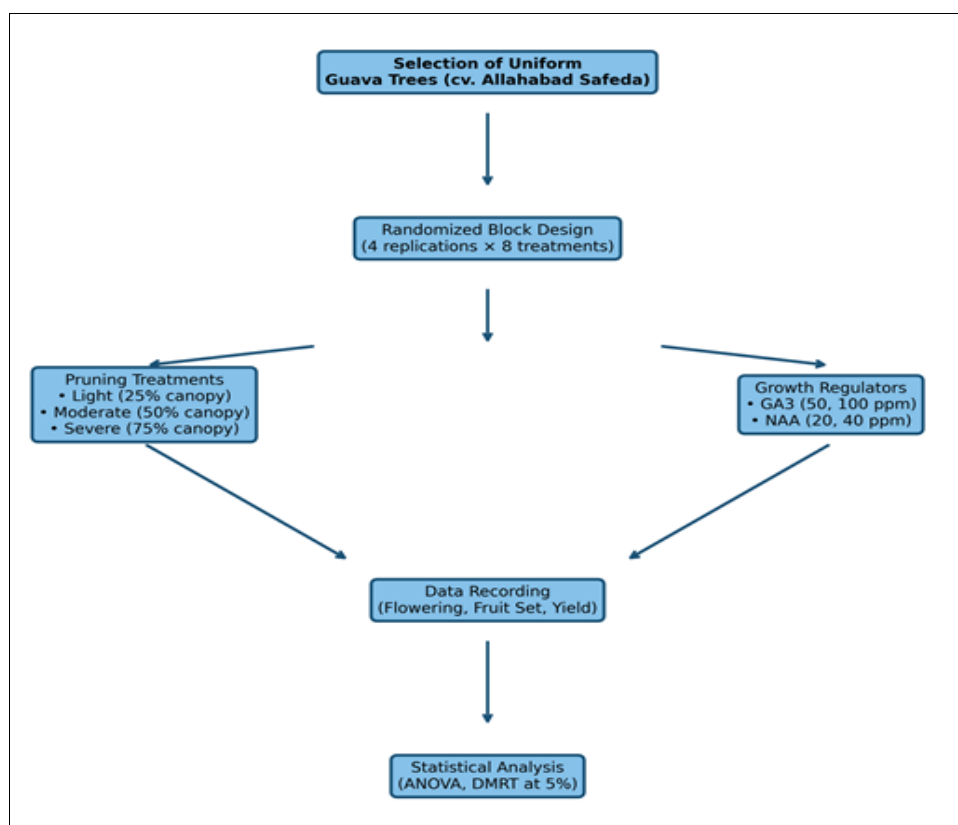


Fig 3: Schematic representation of experimental methodology for pruning and growth regulator evaluation in guava

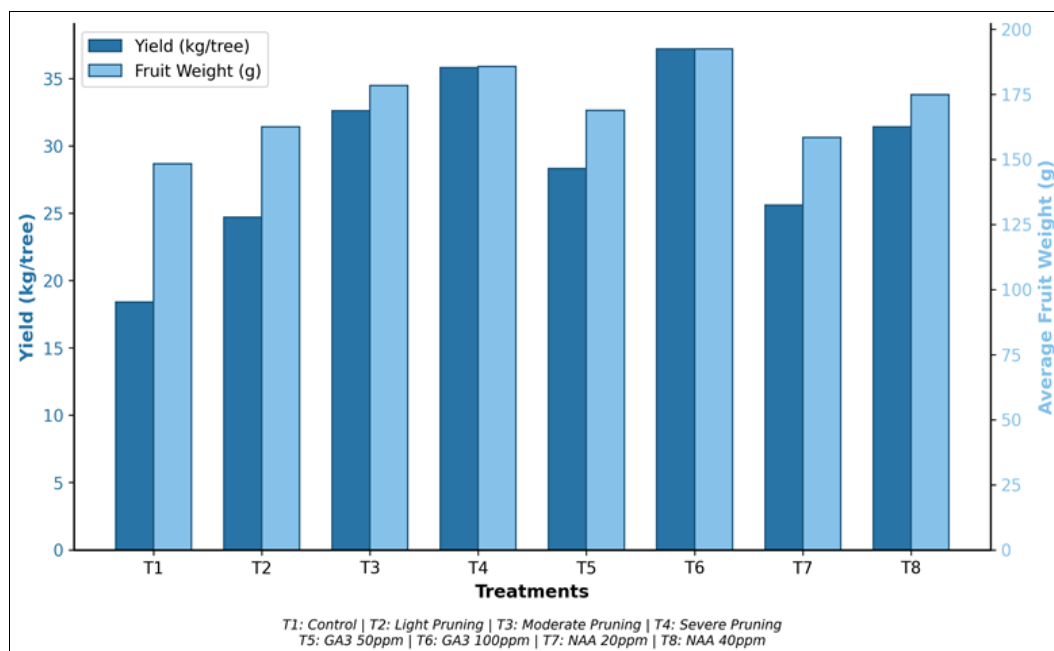


Fig 4: Comparative yield and fruit weight responses across treatments in guava under high density planting

Gibberellic acid at 100 ppm concentration produced results comparable to or exceeding moderate pruning, which can be attributed to its role in promoting flowering initiation and overcoming physiological barriers to reproductive development [9]. The growth regulator appears to substitute partially for the pruning-induced hormonal changes that trigger flowering, offering a less labor-intensive management alternative. However, the combination of both approaches yielded additive benefits, suggesting non-overlapping mechanisms of action that complement each other when applied together.

The delayed flowering under severe pruning treatment despite high eventual flowering percentage reflects the tree's initial prioritization of vegetative recovery following substantial canopy loss. Such responses are consistent with source-sink dynamics where severely pruned trees must first rebuild adequate leaf area before supporting reproductive structures [8]. This observation carries practical implications for harvest timing and market window targeting in commercial production systems.

Fruit quality improvements accompanying yield increases represent economically significant findings. Enhanced total soluble solids and vitamin C content under effective treatments likely result from improved photosynthate availability per fruit when excessive fruit load is avoided through controlled set, combined with better light exposure promoting sugar accumulation [10]. These quality parameters directly influence market acceptance and price premiums available to producers.

Limitations

This research was conducted over a single bearing season, which limits understanding of cumulative treatment effects and potential tree exhaustion from repeated intensive interventions. Year-to-year variation in climatic conditions, particularly temperature extremes during flowering periods, may influence treatment responses differently across seasons. The cultivar-specific nature of these findings restricts direct extrapolation to other guava varieties, which may exhibit distinct growth habits and hormonal

sensitivities. Additionally, economic analysis incorporating labor costs for pruning operations and growth regulator applications was not undertaken, though such assessment would enhance practical utility of recommendations for commercial growers.

Conclusions

This research demonstrates that strategic integration of pruning practices with plant growth regulator applications can substantially enhance reproductive performance and yield in guava under high density planting systems. Moderate pruning removing 50% of canopy volume emerged as the most balanced intervention among pruning intensities examined, promoting improved flowering without the delayed initiation associated with severe pruning. Gibberellic acid at 100 ppm concentration proved highly effective for stimulating flowering and improving fruit set, achieving results comparable to mechanical pruning through hormonal manipulation alone.

The combined application of moderate pruning with GA3 100 ppm exhibited synergistic effects, producing the highest fruit set percentage and maintaining excellent fruit quality characteristics. Yield improvements exceeding 100% over untreated control trees demonstrate the economic potential of these management approaches for commercial guava production. Fruit quality parameters including total soluble solids and vitamin C content improved concurrently with yield increases, indicating that productivity gains need not compromise market-acceptable quality standards.

Naphthalene acetic acid showed moderate benefits at higher concentrations but did not match the effectiveness of gibberellic acid treatments. Light pruning produced intermediate responses insufficient for optimal productivity in high density arrangements where intensive management is necessary to maintain tree vigor within space constraints. Severe pruning, while achieving high eventual flowering percentages, may be counterproductive for timely harvest due to delayed initiation and should be reserved for rejuvenation of neglected orchards rather than routine annual management.

Based on these findings, growers operating high density guava orchards should consider implementing moderate pruning during dormant periods combined with foliar application of GA3 at 100 ppm concentration at flower bud initiation stage. This integrated approach offers practical, cost-effective means to maximize orchard returns while producing fruits meeting quality requirements for premium market channels. Future investigations should evaluate long-term sustainability of these practices and explore optimization of application timing and frequency for different agroclimatic conditions.

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