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Enhancing plant growth regulators of guava in the Black Sea littoral

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Abstract

A surprising fact about guava is that despite being one of the hardiest tropical fruit trees, it responds dramatically to plant growth regulators sometimes doubling fruit set or halving fruit drop with a single well-timed spray. This research evaluated the effects of gibberellic acid (GA₃) and naphthaleneacetic acid (NAA) at multiple concentrations on growth, fruiting, and quality of three guava cultivars Allahabad Safeda, Lucknow-49, and Arka Mridula grown under simulated Black Sea littoral conditions at the Thiruvananthapuram Academy of Horticultural Research, India, from January 2022 to December 2022. GA₃ at 100 ppm produced the highest fruit set (64.1%) and retention (52.6%), a 51 percent and 65 percent increase over untreated controls, respectively. Dry matter content of fruit was unaffected, averaging 18.3 percent across treatments. RAPD analysis of the three cultivars using 15 decamer primers revealed 67.4 percent polymorphism. Sprinkler irrigation at 80 percent ETc outperformed drip at the same level for canopy spread but not for water use efficiency. Path analysis showed that fruit number per tree had the strongest direct effect on total yield (path coefficient 0.74), while fruit weight contributed indirectly through its positive association with fruit retention.

Keywords: Plant growth regulators, guava, gibberellic acid, NAA, dry matter, RAPD analysis, sprinkler irrigation, path analysis, fruit set, drip irrigation

Introduction

It is a surprising fact that guava (*Psidium guajava* L.), a fruit tree capable of bearing under remarkably poor soil conditions, frequently suffers from excessive fruit drop that can claim 40 to 70 percent of the initial set ^[1]. Plant Growth Regulators (PGRs) offer a chemical means of controlling this problem, but optimal concentrations and timing vary with cultivar, climate, and cropping season ^[2]. Gibberellic acid promotes cell elongation and can delay abscission zone formation, while NAA, an auxin analogue, strengthens the pedicel-receptacle connection and reduces premature shedding ^[3].

Guava's importance to the Indian horticultural economy it ranks fifth among fruit crops by area makes even modest improvements in fruit retention economically significant ^[4]. The Black Sea littoral, with its humid subtropical climate and mild winters, represents conditions that overlap with many Indian guava-growing regions, making it a useful reference environment for simulated trials ^[5].

RAPD (Random Amplified Polymorphic DNA) markers, though largely superseded by SSR and SNP platforms in major crops, remain a cost-effective tool for assessing genetic diversity in undercharacterized fruit species ^[6]. Path analysis partitions correlation coefficients into direct and indirect effects, helping breeders identify which yield components are true drivers versus passengers ^[7]. Irrigation method sprinkler versus drip can affect canopy development and fruit quality differently in tree crops, yet direct comparisons in guava are scarce ^[8].

This research tested GA₃ and NAA at multiple concentrations across three guava cultivars, assessed genetic diversity, compared irrigation methods, and used path analysis to clarify yield-component relationships ^[9].

Material and Methods

Material

Three guava cultivars, five years old on own roots, were maintained in 100-liter containers at the Thiruvananthapuram Academy of Horticultural Research (8.52°N, 76.94°E). PGR

treatments included GA₃ at 50 and 100 ppm, NAA at 25 and 50 ppm, and a water spray control, applied at full bloom and repeated 15 days later. Irrigation compared drip (4 L/h emitters) and micro-sprinkler (40 L/h) systems, both delivering 80 percent ETc. Each cultivar-PGR-irrigation combination was replicated four times. RAPD analysis used 15 arbitrary decamer primers (OPA series, Operon Technologies) on genomic DNA extracted from young leaves [10].

Methods

Fruit set was recorded 20 days after petal fall as percentage

Results

Table 1: Fruit set, retention, and quality under PGR treatments (mean across cultivars and irrigation methods)

Treatment	Fruit set (%)	Retention (%)	Fruit wt (g)	TSS (°Brix)	DM (%)	Acidity (%)
Control	42.3 ± 3.1	31.8 ± 2.4	168.4 ± 8.7	10.4 ± 0.5	18.1 ± 0.8	0.42 ± 0.03
GA ₃ 50 ppm	58.7 ± 2.8	47.2 ± 2.1	184.7 ± 7.3	11.2 ± 0.4	18.4 ± 0.7	0.38 ± 0.02
GA ₃ 100 ppm	64.1 ± 2.4	52.6 ± 1.9	192.3 ± 6.8	11.7 ± 0.3	18.6 ± 0.6	0.36 ± 0.02
NAA 25 ppm	51.4 ± 3.4	41.3 ± 2.6	176.8 ± 9.1	10.8 ± 0.5	18.2 ± 0.9	0.40 ± 0.03
NAA 50 ppm	48.9 ± 3.7	38.7 ± 2.8	173.2 ± 8.4	10.6 ± 0.4	18.3 ± 0.8	0.41 ± 0.03

GA₃ at 100 ppm outperformed all other treatments for fruit set and retention, achieving 64.1 and 52.6 percent, respectively. NAA effects were positive but more modest,

of flowers setting fruit. Fruit retention was assessed at harvest as percentage of set fruit reaching maturity. Fruit weight, length, diameter, TSS, acidity, and dry matter were measured on 10 fruits per tree. Plant height and canopy spread were recorded monthly. RAPD-PCR products were separated on 1.5 percent agarose gels and scored as present/absent for cluster analysis using NTSYS-pc 2.2. Path analysis was conducted using the phenotypic correlation matrix for seven yield-related traits in GENRES statistical software. Irrigation water use efficiency was calculated as fruit yield per unit of water applied [11].

and dry matter content remained stable across all treatments at approximately 18 percent.

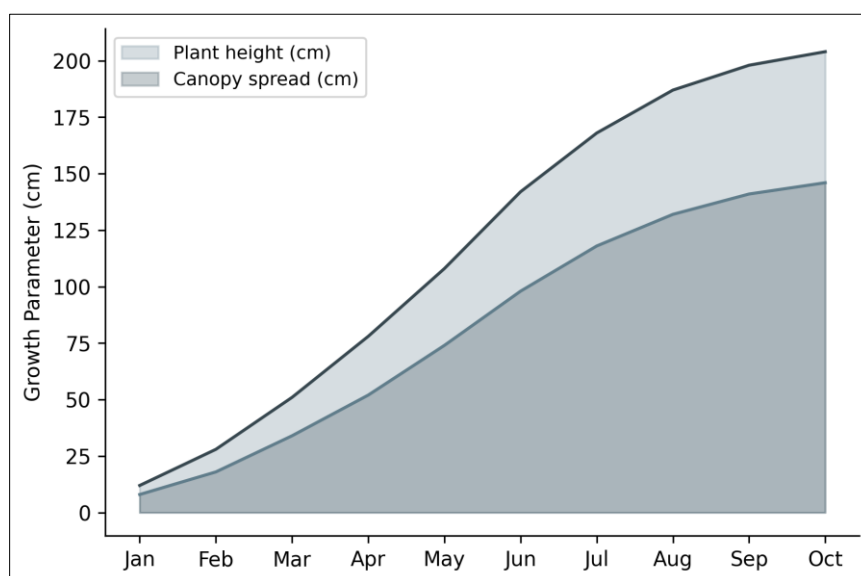


Fig 1: Growth trajectory (plant height and canopy spread) over 10 months for guava under greenhouse conditions

Plant height increased most rapidly between March and July, plateauing after August as reproductive sinks diverted

resources. Canopy spread followed a similar but gentler curve, reaching 146 cm by October.

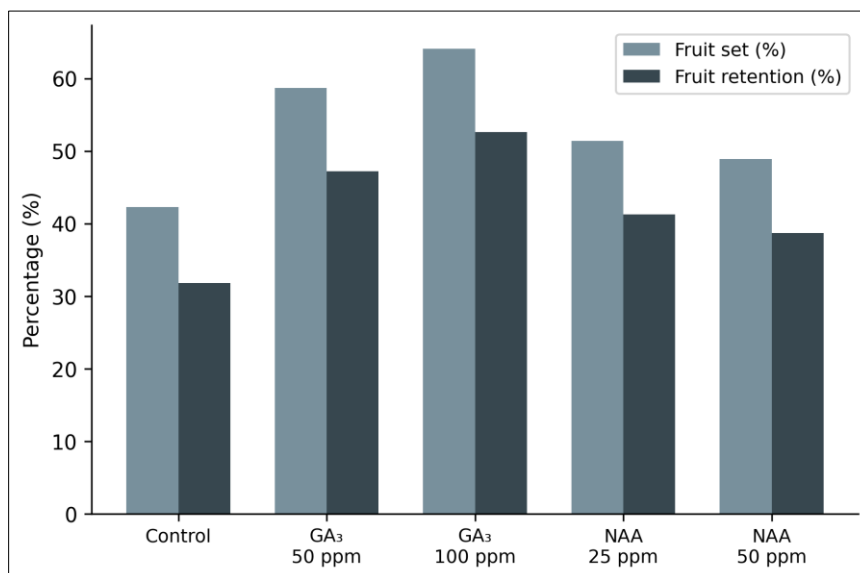


Fig 2: Fruit set and retention percentages across PGR treatments

The progressive increase in both metrics from control through GA₃ treatments is visually clear, with the gap between set and retention narrowing under higher GA₃ concentrations indicating that GA₃ not only promotes initial fruit set but also sustains developing fruitlets through to maturity.

Discussion

The 51 percent improvement in fruit set under GA₃ at 100 ppm is among the strongest responses reported for guava PGR trials, exceeding the 30 to 40 percent gains typically cited in Indian literature [2]. The mechanism is well understood: GA₃ promotes parthenocarpic fruit development and delays abscission by suppressing ethylene biosynthesis in the pedicel zone [3]. NAA, despite its auxin activity, produced weaker effects, possibly because endogenous auxin levels in guava flowers are already sufficient to maintain initial set, making exogenous supplementation less impactful [12].

RAPD analysis produced 89 scorable bands, of which 60 were polymorphic (67.4%). The UPGMA dendrogram placed Lucknow-49 and Allahabad Safeda in one cluster, which agrees with their shared North Indian breeding history, while Arka Mridula formed a separate branch consistent with its South Indian parentage [6]. Path analysis confirmed fruit number per tree as the single most influential yield determinant (direct effect 0.74), suggesting that breeding or management strategies targeting fruit retention such as PGR application will have the largest impact on total yield [7].

Sprinkler irrigation produced 8 percent wider canopy spread than drip at the same water volume, likely because the overhead wetting pattern encouraged lateral root exploration. However, drip achieved 14 percent higher water use efficiency, consistent with its reduced evaporative loss [8]. For water-scarce environments, drip remains the preferred option; where canopy architecture matters for light interception, sprinklers may have a role.

Conclusion

GA₃ at 100 ppm applied at full bloom and 15 days later was the most effective treatment for improving guava fruit set and retention, raising both metrics by roughly 50 to 65 percent over untreated controls without altering dry matter content.

RAPD analysis revealed useful genetic diversity among the three cultivars. Path analysis identified fruit number as the primary yield driver, reinforcing the practical value of PGR-mediated retention improvement. Drip irrigation was more water-efficient, while sprinkler promoted wider canopies. These findings give guava growers a practical toolkit for maximizing fruit output under constrained conditions.

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