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OPTIMIZATION OF GROWTH RETARDANTS FOR CANOPY MANAGEMENT IN GUAVA (*PSIDIUM GUAJAVA* L.) CV. LUCKNOW-49 UNDER ULTRA-HIGH-DENSITY PLANTING

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ABSTRACT
The present investigation was undertaken to optimize the application of growth retardants for canopy management in guava (*Psidium guajava* L.) cv. Lucknow-49 under ultra-high-density planting conditions. The study was conducted from June 2025 to April 2026 at the college orchard of SRM College of Agricultural Sciences, Chengalpattu, Tamil Nadu, India, using four-year-old trees planted at a spacing of 4 × 2 m. The experiment comprised seven treatments involving three levels of paclobutrazol (2.5, 5.0 and 7.5 ml tree^{-1}) combined with two concentrations of ethephon (400 and 600 ppm), along with an untreated control, and was laid out in a Randomized Block Design with three replications. Growth and canopy parameters, including plant height, shoot length, leaf area index (LAI), and east–west and north–south canopy spread, were recorded. The application of paclobutrazol and ethephon significantly restricted vegetative growth compared with the untreated control. Plant height and shoot length were maximum in the control (3.11 m and 35.00 cm, respectively) and minimum under T_6, comprising paclobutrazol 7.5 ml tree^{-1} + ethephon 600 ppm (2.30 m and 26.66 cm, respectively). Canopy spread was also greatest in the control, measuring 4.08 m in the east–west direction and 3.96 m in the north–south direction, while the minimum spread was recorded under T_6 (3.20 and 3.08 m, respectively). In contrast, LAI increased with the application of the growth retardants and reached its maximum under T_4 (paclobutrazol 5.0 ml tree^{-1} + ethephon 600 ppm) at 2.91, followed by a decline at the higher paclobutrazol dose. Overall, the results demonstrated that combined application of paclobutrazol and ethephon effectively regulated vegetative and canopy growth in guava under ultra-high-density planting, with T_6 producing the strongest canopy restriction and T_4 providing comparatively favourable leaf area development.

KEYWORDS: Guava, Lucknow-49, paclobutrazol, ethephon, canopy management, ultra-high-density planting

INTRODUCTION
Guava (*Psidium guajava* L.), often referred to as the “apple of the tropics,” belongs to the family Myrtaceae and ranks among India’s most commercially important fruit crops. India leads the world in guava production, accounting for 45% of global production, followed by China and Thailand. The crop is cultivated over an area of 357.64 Mha, with a production of 5262.73 MT and a productivity of 14.72 MT ha^{-1}. In Tamil Nadu, guava is cultivated over an area of 14.56 Mha, with a productivity of 25.26 MT ha^{-1} (Indiastat, 2024). Guava fruit is valued for its high ascorbic acid content and its rich complement of antioxidant compounds, which underpin its demand in both fresh and processed markets (Butt et al., 2025). Among commercial cultivars, Lucknow-49 is widely preferred by growers for its high yield potential and desirable fruit quality (Reshma et al., 2025).

Under tropical conditions, guava flowers throughout the year, resulting in three distinct cropping seasons: Ambe bahar, Mrig bahar, and Hasta bahar. Reliance on natural bahar cropping leads to erratic and non-synchronous flowering, market gluts during periods of poor fruit quality, and consequent economic losses (Sahu et al., 2025). Securing a high-value winter Mrig bahar crop therefore depends on regulating the preceding rainy-season crop, which is characterised by inferior fruit quality and increased pest incidence.

Chemical crop regulation offers a physiologically targeted approach to shifting this cropping pattern (Gopu et al., 2017). Paclobutrazol restricts shoot elongation by inhibiting gibberellin biosynthesis, thereby redirecting assimilates from vegetative growth towards reproductive development (Rademacher, 2000; Gopu and Balamohan, 2015a). Ethephon releases ethylene, which promotes synchronised defoliation, regulates flower and fruit abscission in the unwanted rainy-season crop, and hastens fruit maturity, while also accelerating the biochemical changes associated with ripening in the retained crop. When applied in combination, paclobutrazol and ethephon are expected to shift the leaf carbohydrate-to-nitrogen balance towards greater carbohydrate accumulation, thereby favouring floral bud differentiation, while the accompanying ethylene activity may help regulate fruit retention and ripening (Gopu and Balamohan, 2015b).

The effects of paclobutrazol and ethephon on vegetative growth regulation and fruit quality have been documented individually across several fruit crops (Dutta, 2022), while only a limited number of studies have evaluated their combined application in guava (Singh and Kaur, 2018). However, most previous studies have evaluated these compounds across a broad range of concentrations without systematically identifying the combination that maximises fruit retention and quality. Moreover, reports on the paclobutrazol dose beyond which its beneficial effects plateau or decline in guava remain scarce. Therefore, the present investigation was undertaken to evaluate the combined effects of paclobutrazol and ethephon on the growth characteristics of guava cv. Lucknow-49 under the agro-climatic conditions of Tamil Nadu.

MATERIAL AND METHODS

The present investigation was conducted from June 2025 to April 2026 in the college orchard of SRM College of Agricultural Sciences, Chengalpattu, Tamil Nadu, India. The experimental site is located at 12°23′19.7″ N latitude and 79°44′37.4″ E longitude, at a mean elevation of approximately 50 m above mean sea level. It receives an average annual rainfall of approximately 995 mm. Four-year-old guava trees of the cultivar Lucknow-49, planted at a spacing of 4 × 2 m, were used for the study, accommodating 1,250 plants per hectare. The experiment consisted of seven treatments namely T_1: Paclobutrazol 2.5 ml/tree + Ethephon 400 ppm, T_2: Paclobutrazol 2.5 ml/tree + Ethephon 600 ppm, T_3: Paclobutrazol 5.0 ml/tree + Ethephon 400 ppm, T_4: Paclobutrazol 5.0 ml/tree + Ethephon 600 ppm, T_5: Paclobutrazol 7.5 ml/tree + Ethephon 400 ppm, T_6: Paclobutrazol 7.5 ml/tree + Ethephon 600 ppm and T_7: Control. Paclobutrazol (40% SC) was applied as a soil drench in 1 lit. of water per tree through a shallow trench opened around the root zone, whereas ethephon was applied as a foliar spray. Both compounds were applied as a single treatment before the onset of the rainy-season flowering flush. The experiment was laid out in a Randomized Block Design with three replications, with each treatment represented by an appropriate number of uniformly managed plants in each block. All other recommended cultural practices were maintained uniformly across the treatments.

Plant height was recorded for each treated tree using a graduated measuring pole as the vertical distance from ground level to the tip of the tallest growing shoot and expressed in metres. Shoot length was measured on tagged shoots of each tree using a measuring tape, recording the extension growth from the point of tagging to the shoot tip. The mean shoot length for each treatment was expressed in centimetres. Leaf area index was calculated for each treatment as the ratio of the total leaf area of the canopy to the ground area occupied by the tree. Leaf area was estimated from representative sample leaves collected from the four cardinal directions of the canopy. Canopy spread was recorded along two directions, east–west and north–south, by measuring the horizontal extension of the canopy along each axis using a measuring tape, and the values were expressed in metres. The data recorded for the above vegetative parameters were subjected to analysis of variance appropriate for the Randomized Block Design. Treatment means were compared using the critical difference (CD) test at the 5% level of probability ($p \leq 0.05$), and the standard error of difference (S.Ed. ±) was calculated for each parameter.

RESULTS AND DISCUSSION

Plant height

Data on plant height (Table 1) showed a significant restriction of vertical growth in all paclobutrazol–ethephon combinations compared with the untreated control trees, with T_7 recording the greatest plant height (3.11 m) and T6 the lowest (2.30 m). Brar (2010) reported that untreated guava control trees attained a significantly greater height (3.79 m) than paclobutrazol-treated trees (3.49 m) in a spacing trial, supporting the greater vegetative growth observed under untreated conditions in the present study. Conversely, Murti et al. (2001) reported a marked reduction in tree height in mango cv. Alphonso following the application of paclobutrazol at 10 g a.i. tree^{-1}. Similar results were also reported by Ghirisan et al. (2025).

Shoot length

Shoot length (Table 1) was greatest under T_7 (35.00 cm) and lowest under T_6 (26.66 cm). Blaikie et al. (2004), working on mango cv. Kensington Pride, reported that untreated trees produced longer vegetative flushes than paclobutrazol-treated trees, with both shoot and root phenology being markedly curtailed by paclobutrazol application. This finding supports the greater shoot length observed under the untreated control in the present study. Similarly, Kotur (2012) reported a significant reduction in twig length in mango following paclobutrazol application, which is consistent with the greater reduction in shoot length observed at the higher paclobutrazol doses in the present investigation.

Leaf area index

Leaf area index (LAI) increased with the application of paclobutrazol and ethephon treatments and reached its maximum under T_4 (2.91), followed by a decline at the higher paclobutrazol doses (T_5 and T_6). However, the LAI under T_6 remained higher than that of the untreated control (T_7) (Table 1). Baskaran et al. (2011), in acid lime, reported that lower or soil-applied doses of paclobutrazol supported greater canopy development and vegetative growth than more intensive treatments, which is broadly consistent with the increase in LAI observed up to T_4 in the present study. Similarly, Gupta and Bisht (2005), working on pear cv. Bagugosa, reported that paclobutrazol application at 10 ml tree^{-1} significantly reduced leaf area, supporting the decline in LAI observed at the higher paclobutrazol doses in the present investigation.

Canopy spread (East–West)
Canopy spread in the east–west direction (Fig. 1) was greatest under T_7 (4.08 m) and lowest under T_6 (3.20 m). Charnvichit et al. (1991), working on mango cv. Nam Dok Mai following hard pruning, reported that the canopies of untreated control trees expanded sufficiently to overlap, whereas paclobutrazol-treated trees exhibited a 15.81% reduction in canopy spread. This finding supports the greater canopy spread observed under the untreated control in the present study. Similarly, Chanana and Gill (2007) reported that paclobutrazol application at 8 ml tree^{-1} resulted in the minimum canopy spread in guava, which is consistent with the reduced canopy spread observed under the higher paclobutrazol dose (T_6) in the present investigation.

Canopy spread (North–South)
The north–south canopy spread (Fig. 2) was greatest under T_7 (3.96 m) and lowest under T_6 (3.08 m). Faizan, Mohammad and Ganesh (2000), in a study on litchi, reported reduced vegetative and canopy growth following paclobutrazol application compared with untreated trees, which is consistent with the greater canopy spread observed under the untreated control in the present study. Similarly, Singh and Bal (2006) reported that guava cv. Allahabad Safeda treated with ethephon at 1000 ppm recorded the minimum tree height and canopy volume, supporting the pronounced reduction in canopy spread observed under T_6.

CONCLUSION
The present study demonstrated that combined application of paclobutrazol and ethephon effectively regulated vegetative growth and canopy development in guava cv. Lucknow-49 under ultra-high-density planting. The treatment T_6 (paclobutrazol 7.5 ml tree^{-1} + ethephon 600 ppm) recorded the greatest reduction in plant height, shoot length, and canopy spread. Treatment T_4 (paclobutrazol 5.0 ml tree^{-1} + ethephon 600 ppm) recorded the highest leaf area index (2.91), indicating better canopy balance at a moderate paclobutrazol dose. The untreated control exhibited excessive vegetative growth and the widest canopy spread. Thus, paclobutrazol, in combination with ethephon, can be used effectively for canopy regulation and for maintaining a compact tree architecture under ultra-high-density planting.

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Table 1. Effect of growth retardants on plant height (m), shoot length (cm), and leaf area index (m²/m²) of guava cv. Lucknow-49

Treatments	Plant height (m)	Shoot length (cm)	Leaf area index (m²/m²)
T_1	2.80	33.33	2.49
T_2	2.70	32.66	2.59
T_3	2.51	29.38	2.70
T_4	2.38	29.00	2.91
T_5	2.33	28.32	2.41
T_6	2.30	26.66	2.29
T_7	3.11	35.00	2.10
S.Ed±	0.12	1.38	0.11
CD (P=0.05)	0.27	3.08	0.25

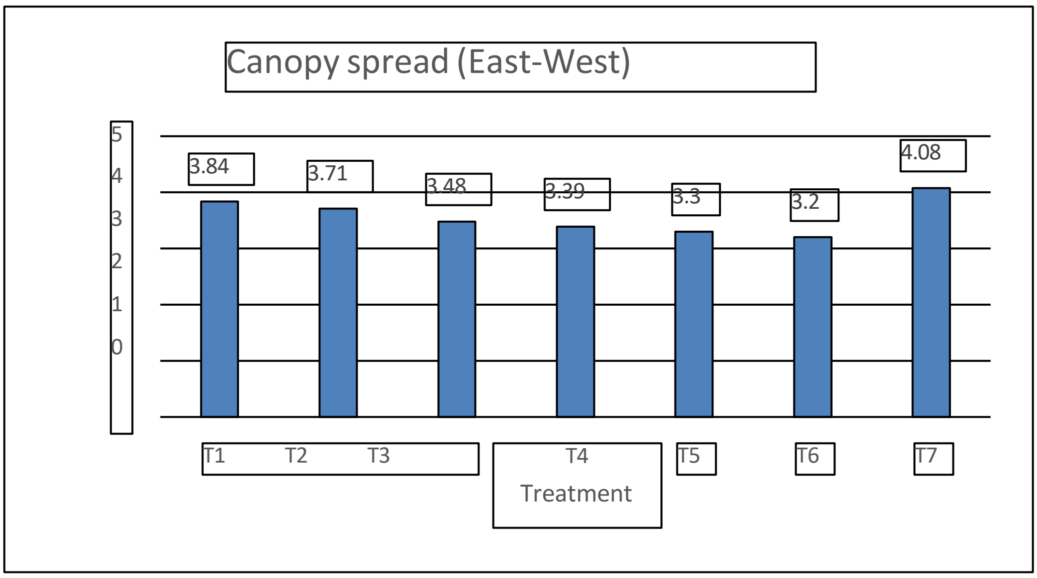

Fig 1. Effect of growth retardants on canopy spread (East-West) of guava cv. Lucknow-49

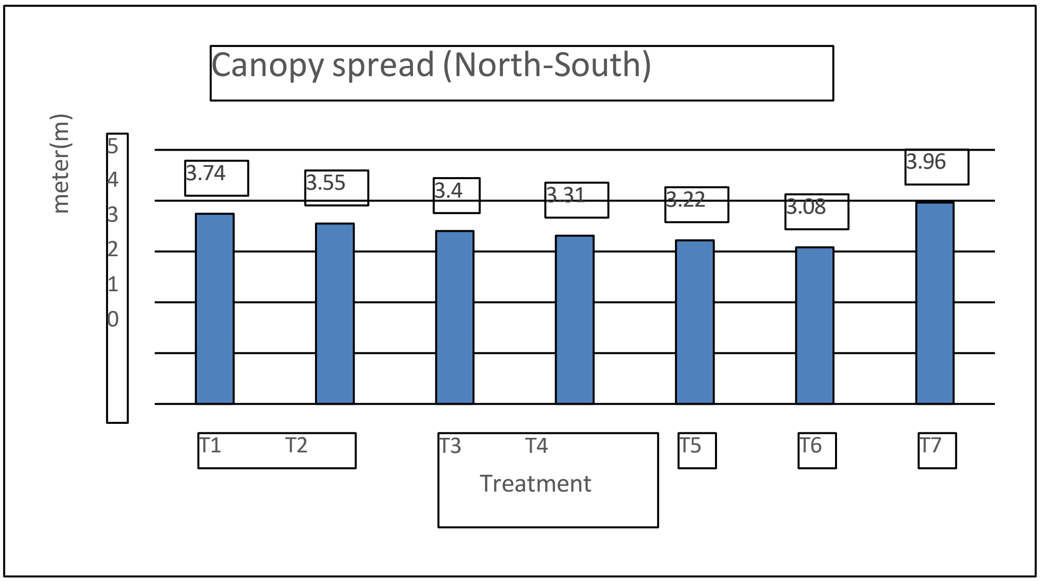

Fig 2. Effect of growth retardants on canopy spread (North-South) of guava cv. Lucknow-49