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Effect of foliar application of GA_3 and NAA on growth and yield of ber (*Ziziphus mauritiana* Lamk.) cv. Thai Apple

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ABSTRACT

A field experiment was conducted during 2025–26 to evaluate the effects of foliar application of gibberellic acid (GA_3) and naphthalene acetic acid (NAA) on growth and yield of ber (*Ziziphus mauritiana* Lamk.) cv. Thai Apple. The experimental plants were located at Fatehgarh, Hanumangarh, Rajasthan, and the investigation was conducted through the Department of Horticulture, Faculty of Agriculture, Tanta University, Sri Ganganagar, Rajasthan. Eight treatments were evaluated in a Randomized Block Design with three replications, with one six-year-old tree representing each treatment within each replication. Foliar sprays were applied at the new vegetative flush, pre-flowering and fruit-set stages. The combined treatment T_8 (GA_3 15 ppm + NAA 10 ppm) recorded the highest increase in plant height (0.89 m), total plant height (3.73 m), number of branches plant-1 (59.14), fruit length (5.15 cm) and fruit diameter (4.83 cm). The same treatment also recorded the highest number of fruits plant-1 (764), average fruit weight (51.80 g), fruit yield plant-1 (39.57 kg) and fruit yield (110.00 q ha⁻¹). Initial plant height was non-significant, whereas the other measured growth and yield attributes showed significant treatment responses. The results indicate that T_8 produced the highest measured growth and yield responses under the conditions of the present experiment.

Keywords: *Ziziphus mauritiana*, Thai Apple, GA_3 , NAA, Plant growth regulators, Fruit yield, RBD

1. Introduction

Ber (*Ziziphus mauritiana* Lamk.) is an important fruit crop of arid and semi-arid regions and is valued for its adaptability to relatively harsh production environments. The crop is widely cultivated in Rajasthan and other parts of northern India, where plant growth, flowering, fruit retention and yield are influenced by cultivar, pruning, environment and crop-management practices. Reviews of ber production identify fruit drop, fruit retention, fruit set and fruit size as important production traits and discuss plant growth regulators as tools for modifying these processes (Singh *et al.*, 2020) [1].

Plant growth regulators can modify vegetative and reproductive development. Gibberellins are associated with cell expansion and elongation, while auxins such as NAA participate in fruit development and abscission-related processes. Their effects are concentration- and stage-dependent, and responses can differ among crops and cultivars (Rademacher, 2015; Kumar *et al.*, 2014) [3, 2]. In ber, previous studies have reported effects of GA_3 and NAA on fruit retention, fruit size, yield and quality (Karole *et al.*, 2016; Yadav *et al.*, 2021) [4, 5]. Recent field research in Rajasthan has also demonstrated that plant bio-regulator treatments can influence vegetative growth, fruit yield and fruit quality of ber (Shashi *et al.*, 2022) [6], while recent work from ICAR-CIAH has shown that GA_3 application can affect fruit set and retention under hot-arid conditions (Kumawat *et al.*, 2025) [7].

The present investigation was therefore undertaken to evaluate selected foliar applications of GA_3 and NAA on growth, fruit size and yield of ber cv. Thai Apple under the conditions of north-western Rajasthan. The objective was to identify treatment responses for the measured growth and yield parameters.

2. Materials and Methods

2.1 Experimental site and plant material

The investigation was conducted during 2025–26 through the Department of Horticulture, Faculty of Agriculture, Tanta University, Sri Ganganagar, Rajasthan, India. The actual experimental ber plants were located at Fatehgarh, Hanumangarh, Rajasthan (335801), in the Irrigated North-Western Plain Zone (1b) of Rajasthan. Thus, Tanta University represents the institutional/departamental site of the investigation, whereas Fatehgarh represents the field location of the experimental plants. Six-year-old ber plants of cv. Thai Apple were selected.

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2.2 Experimental design and treatments

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. The experimental layout in the thesis shows 6 m × 6 m plant spacing. One tree represented one experimental unit for each treatment within each replication, giving $8 \times 3 = 24$ experimental trees. The 6 m × 6 m spacing corresponds to a

spatial footprint of approximately 36 m² per tree and a theoretical plant population of 277.78 trees ha⁻¹. Treatments were randomly allocated within each replication according to the experimental layout. The thesis does not define a separate multi-tree plot boundary because each treatment–replication combination comprised one tree; therefore, no additional plot size is assumed.

Treatment	Treatment description
T ₁	Control
T ₂	GA ₃ @ 15 ppm
T ₃	GA ₃ @ 30 ppm
T ₄	GA ₃ @ 45 ppm
T ₅	NAA @ 10 ppm
T ₆	NAA @ 20 ppm
T ₇	NAA @ 30 ppm
T ₈	GA ₃ @ 15 ppm + NAA @ 10 ppm

2.3 Observations recorded

Observations pertaining to growth and yield parameters were recorded at appropriate stages of crop growth. Growth parameters included initial plant height, increase in plant height at harvest, total plant height at harvest, number of branches per plant, fruit length and fruit diameter. Yield parameters included number of fruits per plant, average fruit weight, fruit yield per plant and fruit yield per hectare. Plant height was measured from ground level to the apical growing point; increase in height was calculated from the difference between initial and total height. Fruit length and diameter were measured using a Vernier caliper. Fruits were counted manually at maturity, average fruit weight was determined from fruit weight observations, and cumulative fruit weight was used to obtain yield per plant. Fruit yield per hectare was expressed in quintals per hectare.

2.4 Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design following Panse *et al.* (1984) [8]. The statistical model was $Y_{ij} = \mu + \tau_i + \beta_j + e_{ij}$,

where μ is the overall mean, τ_i is the treatment effect, β_j is the replication effect and e_{ij} is the experimental error. With eight treatments and three replications, the treatment, replication and error degrees of freedom were 7, 2 and 14, respectively. Treatment effects were tested by the *F*-test at the 5% probability level. The standard error of the mean was derived from the error mean square, and CD at $P = 0.05$ was calculated as $t_{0.025, df} \times \sqrt{(2 \times \text{MSE}/r)}$ when the treatment effect was significant.

3. Results

3.1 Growth and growth attributes

The results presented in Table 1 revealed that foliar application of GA₃ and NAA influenced plant height and branching of ber cv. Thai Apple. T₈ (GA₃ 15 ppm + NAA 10 ppm) recorded the highest increase in height at harvest (0.89 m) and total plant height at harvest (3.73 m), whereas the control recorded 0.46 m and 3.29 m, respectively. Initial plant height was non-significant among treatments. The same treatment recorded the highest number of branches per plant (59.14).

Table 1. Effect of foliar application of GA₃ and NAA on growth parameters of ber cv. Thai Apple

Treatment	Initial plant height (m)	Increase in height at harvest (m)	Total plant height at harvest (m)	Branches plant ⁻¹
T ₁ Control	2.83	0.46	3.29	39.16
T ₂ GA ₃ 15 ppm	2.85	0.61	3.46	45.84
T ₃ GA ₃ 30 ppm	2.84	0.80	3.64	52.72
T ₄ GA ₃ 45 ppm	2.85	0.74	3.59	49.45
T ₅ NAA 10 ppm	2.82	0.56	3.38	40.28
T ₆ NAA 20 ppm	2.85	0.67	3.52	54.63
T ₇ NAA 30 ppm	2.83	0.59	3.42	46.18
T ₈ GA ₃ 15 ppm + NAA 10 ppm	2.84	0.89	3.73	59.14
S.Em. (±)	0.03	0.01	0.04	0.63
CD ($P = 0.05$)	0.09	0.02	0.14	1.93

The results presented in Table 2 showed that the combined treatment T₈ recorded the highest fruit length (5.15 cm) and fruit diameter (4.83 cm), compared with 3.38 cm and 3.11 cm, respectively, under

the control. The treatment response for fruit-size attributes was significant at the 5% probability level.

Table 2. Effect of foliar application of GA₃ and NAA on fruit size of ber cv. Thai Apple

Treatment	Fruit length (cm)	Fruit diameter (cm)
T ₁ Control	3.38	3.11
T ₂ GA ₃ 15 ppm	4.05	3.83
T ₃ GA ₃ 30 ppm	4.69	4.35
T ₄ GA ₃ 45 ppm	4.91	4.57
T ₅ NAA 10 ppm	3.85	3.51
T ₆ NAA 20 ppm	4.33	4.01
T ₇ NAA 30 ppm	3.99	3.75
T ₈ GA ₃ 15 ppm + NAA 10 ppm	5.15	4.83
S.Em. (±)	0.05	0.03
CD (<i>P</i> = 0.05)	0.16	0.10

3.2 Yield and yield attributes

Table 3. Effect of foliar application of GA₃ and NAA on yield parameters of ber cv. Thai Apple

Treatment	Fruits plant ⁻¹	Average fruit weight (g)	Yield plant ⁻¹ (kg)	Yield (q ha ⁻¹)
T ₁ Control	523	42.50	22.22	61.77
T ₂ GA ₃ 15 ppm	594	44.30	26.31	73.14
T ₃ GA ₃ 30 ppm	648	46.83	30.34	84.34
T ₄ GA ₃ 45 ppm	673	48.41	32.57	90.54
T ₅ NAA 10 ppm	614	45.63	28.01	77.86
T ₆ NAA 20 ppm	695	47.91	33.29	92.54
T ₇ NAA 30 ppm	725	49.60	35.96	99.96
T ₈ GA ₃ 15 ppm + NAA 10 ppm	764	51.80	39.57	110.00
S.Em. (±)	6.94	0.43	0.42	0.74
CD (<i>P</i> = 0.05)	21.05	1.32	1.30	2.26

4. Discussion

The present study showed treatment-dependent responses of ber cv. Thai Apple to foliar GA₃ and NAA application. The combined treatment T₈ recorded the highest values for the measured growth and fruit-size parameters, while initial plant height was statistically non-significant. Such treatment- and concentration-dependent responses are consistent with the broader literature on PGR use in ber (Singh *et al.*, 2020; Karole *et al.*, 2016) [1, 4].

The greater plant height and fruit dimensions under T₈ may be associated with the known roles of gibberellins in cell expansion and elongation and of auxins in fruit development and abscission-related processes. These mechanisms provide a physiological basis for interpreting the observed response, but the present experiment did not measure endogenous hormones, cell division, photosynthesis or nutrient translocation; therefore, these mechanisms should be regarded as interpretive explanations rather than directly measured effects (Rademacher, 2015; Kumar *et al.*, 2014) [3, 2].

The yield response was significant for fruit number, average fruit weight, yield plant⁻¹ and yield ha⁻¹. T₈ produced 764 fruits plant⁻¹, 51.80 g average fruit weight, 39.57 kg plant⁻¹ and 110.00 q ha⁻¹. Comparable positive effects of GA₃ and NAA on fruit size and yield of ber have been reported under other experimental conditions (Yadav *et al.*, 2021) [5], while recent Rajasthan research has shown that plant bio-regulator treatments can modify ber growth and yield (Shashi *et al.*, 2022) [6].

Overall, the statistically significant responses were confined to the measured treatment effects listed above; initial plant height was non-significant. The results therefore support treatment-specific differences under the conditions of this single-season, single-location experiment and should be confirmed across seasons and locations before broader recommendation.

5. Conclusion

Under the conditions of the 2025–26 investigation, foliar application of GA₃ and NAA significantly affected increase in plant height, total plant height, branches plant⁻¹, fruit length, fruit diameter, fruits plant⁻¹, average fruit weight, fruit yield plant⁻¹ and fruit yield ha⁻¹. T₈ recorded 0.89 m increase in height, 3.73 m total height, 59.14 branches plant⁻¹, 5.15 cm fruit length, 4.83 cm fruit diameter, 764 fruits plant⁻¹, 51.80 g average fruit weight, 39.57 kg plant⁻¹ and 110.00 q ha⁻¹.

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