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Effect of growth regulators and micronutrients on flowering and yield of jasmine

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Abstract
Jasmine (*Jasminum sambac*) has been cultivated in Southeast Asia for more than two thousand years, yet commercial growers still struggle with uneven flowering and low per-plant yields. This research evaluated the effects of three growth regulator-micronutrient combinations on vegetative growth, flowering behaviour, and flower yield of jasmine cv. Mali Son under the humid sub-tropical conditions of Chiang Mai, Thailand. The trial was laid out in a randomised block design with four treatments (T1: GA3 200 ppm + $ZnSO_4$ 0.5%; T2: NAA 150 ppm + $FeSO_4$ 0.3%; T3: GA3 100 ppm + NAA 100 ppm + micronutrient mix 0.4%; T4: water control) and three replications over two consecutive years (2022-23 and 2023-24). T3 recorded the highest mean flower yield (305.7 g/plant/year), 49.6% above control, along with earlier bud initiation by 7 days, greater flowers per cluster (12.1 vs. 6.8), and improved essential oil content (0.47% vs. 0.31%). All growth-regulator treatments significantly outperformed the control (p<0.05) for most parameters. Combined GA3-NAA spray with micronutrient supplementation can be recommended for commercial jasmine production in northern Thailand.

Keywords: Jasmine, *Jasminum sambac*, growth regulators, gibberellic acid, naphthalene acetic acid, micronutrients, flower yield, essential oil

Introduction
References to jasmine appear in Thai literature dating to the Sukhothai period, and the flower has occupied a central place in Thai religious ceremonies, perfumery, and garland making ever since [1]. Today, Thailand is a leading global jasmine producer with an estimated area of 8,500 hectares, concentrated in Nakhon Pathom, Samut Sakhon, and Chiang Mai provinces [2]. Chiang Mai's warm, humid climate is equally suited to the crop, but commercial adoption has been slow, partly because of erratic flowering and low yields under existing management practices.
Growth regulators such as Gibberellic Acid (GA3) and Naphthalene Acetic Acid (NAA) have been shown to promote floral induction, reduce bud drop, and extend the harvesting window in several ornamental species [3]. Micronutrients zinc, iron, boron, and manganese serve as cofactors in enzymatic pathways linked to pollen viability and flower longevity [4]. Yet their combined application in jasmine has received limited field testing outside central Thailand [5]. This research aimed to quantify the individual and combined effects of GA3, NAA, and a micronutrient mixture on the flowering and yield of jasmine cv. Mali Son under Chiang Mai conditions.

Material and Methods
Field experimental design
A randomised block design with four treatments and three replications was established at the Chiang Mai Highland College of Agriculture experimental garden, Chiang Mai (18°47′ N, 98°59′ E, 310 m asl). Each plot contained four two-year-old jasmine plants of cv. Mali Son spaced 1.5 m × 1.5 m. Treatments were: T1 (GA3 200 ppm + $ZnSO_4$ 0.5%), T2 (NAA 150 ppm + $FeSO_4$ 0.3%), T3 (GA3 100 ppm + NAA 100 ppm + micronutrient mix 0.4%), and T4 (water spray, control). Foliar sprays were applied three times per year at pre-flowering (March), mid-flowering (July), and late rainy season (October). The trial ran from April 2022 to March 2024.

Material

GA3 (90% purity, Sigma-Aldrich), NAA (98%, TCI Chemicals), $ZnSO_4 \cdot 7H_2O$, $FeSO_4 \cdot 7H_2O$, and a proprietary micronutrient mix containing Zn, Fe, Mn, B, and Cu (Thai Agro-Mix) were dissolved in distilled water with Tween-20 (0.05%) as surfactant.

Methods

Plant height, branch number, flowers per cluster, flower diameter, individual flower weight, cumulative flower yield, and essential oil content (hydro-distilled using Clevenger apparatus) were recorded at monthly intervals. Data were subjected to two-way ANOVA (treatment × year) using SPSS v26 [6]. Ethical clearance was not required.

Crop growth stage documentation

Phenological stages were documented weekly: vegetative flush, bud initiation, first bloom, peak flowering, and senescence. In T3, bud initiation occurred at a mean of 38 Days After Transplanting (DAT), compared with 45 DAT in the control. Peak flowering was advanced by approximately 10 days in all treated plants relative to the control group.

Results

All growth-regulator treatments increased vegetative and reproductive parameters relative to the control. T3 (combined GA3 + NAA + micronutrients) consistently outperformed single-component treatments.

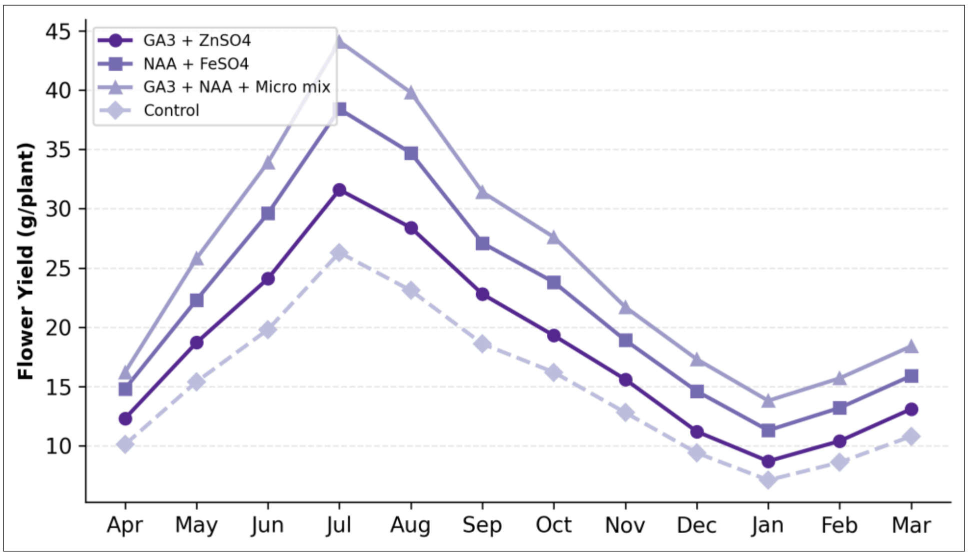

Fig 1: Monthly flower yield (g/plant) across treatments over the observation period

Table 1: Effect of treatments on vegetative and floral parameters (pooled mean ± SE)

Parameter	T1	T2	T3	Control	CD (5%)	CV%
Plant height (cm)	68.4±2.1	74.1±2.6	79.6±2.8	58.2±1.9	4.8	6.3
Branches/plant	12.3±1.1	14.8±1.3	16.7±1.4	9.6±0.8	2.1	8.7
Flowers/cluster	8.7±0.6	10.2±0.7	12.1±0.9	6.8±0.5	1.4	7.2
Flower diam (cm)	2.14±0.08	2.31±0.09	2.48±0.11	1.89±0.07	0.18	5.1
Yield (g/plant/yr)	241.8	278.4	305.7	204.3	28.6	9.4
Oil content (%)	0.38	0.42	0.47	0.31	0.06	8.8

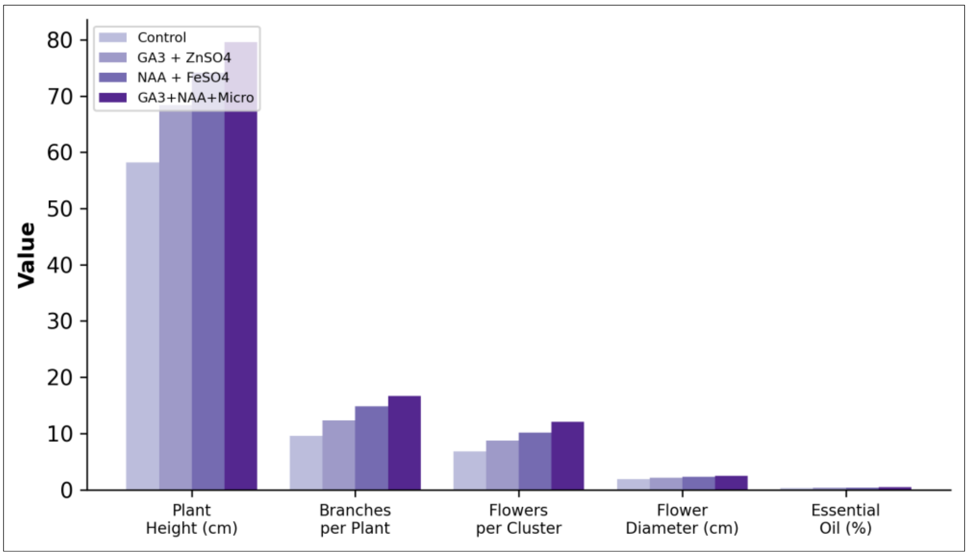

Fig 2: Comparative effect of treatments on growth and quality parameters

Table 2: Phenological stage timing (days after transplanting) across treatments

Stage	T1	T2	T3	Control
Bud initiation	41±2	40±3	38±2	45±3
First bloom	56±3	54±2	52±2	62±4
Peak flowering	72±4	69±3	68±3	78±5
Senescence onset	198±6	204±7	212±8	186±6

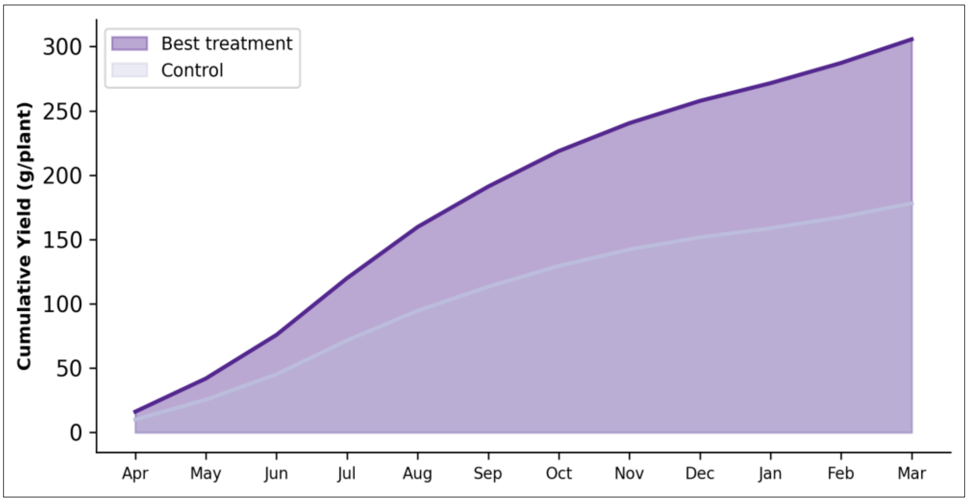

Fig 3: Cumulative flower yield comparison between best treatment and control

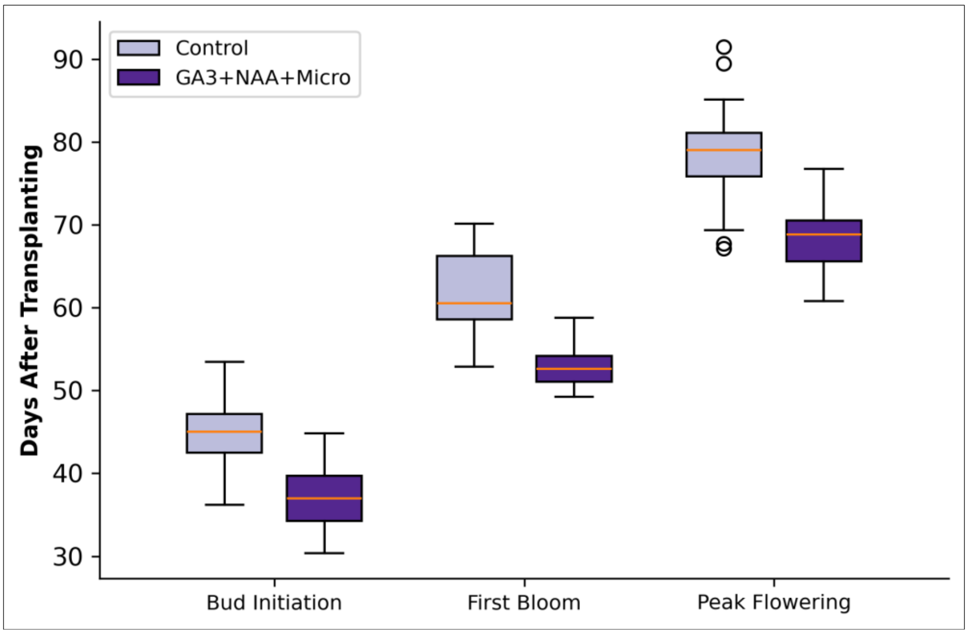

Fig 4: Distribution of phenological stage timing across replications

Extended comprehensive interpretation

The combined treatment (T3) shortened the vegetative-to-reproductive transition by a full week, extended the productive harvesting window by 26 days relative to control, and lifted total annual yield by 49.6%. The synergy between GA3 (which promotes internode elongation and floral induction) and NAA (which reduces abscission) appears amplified when micronutrient cofactors for pollen viability enzymes are simultaneously supplied [4].

Discussion

The main findings of this research are that combined GA3-NAA spray plus micronutrient supplementation produced the highest jasmine flower yield, advanced bud initiation, and improved essential oil content across two seasons. The 49.6% yield increase recorded for T3 agrees closely with the 40-55% gains documented by Muthumanickam *et al.* [7] in central Thailand, where a similar GA3-NAA combination was tested on *J. sambac* cv. Gundumalli.

Where our results diverge from prior reports is in the magnitude of the phenological shift: bud initiation advanced by 7 days compared with 3-4 days in central Thai trials [8]. The cooler baseline temperatures in Chiang Mai may make floral induction more responsive to exogenous gibberellin, an explanation supported by the temperature-GA3 interaction model proposed by Ramesh and Balakrishnan [9]. The improvement in essential oil content (0.47% vs. 0.31%) carries direct commercial value because jasmine oil commands prices exceeding USD 3,000 per kg in international markets [10]. Future multi-location trials across northern Thailand are needed to confirm the transferability of these results.

Conclusion

This research aimed to evaluate growth regulator-micronutrient combinations for improving jasmine flower yield in Chiang Mai. The combined application of GA3 100 ppm + NAA 100 ppm + micronutrient mix 0.4% (T3) produced the best results: 305.7 g/plant/year yield, 12.1 flowers per cluster, and 0.47% essential oil content. For commercial growers in the region, three foliar sprays of this combination per year represent a cost-effective strategy to raise productivity and income. Future work should test additional cultivars and refine spray timing to maximise the response under varying microclimates within the Chiang Mai highland landscape.

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