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Salicylic Acid Triggered Flowering in The Biomedical Ornamental Jasminum Sambac L.

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Abstract
Jasminum sambac L, Madurai Malli, the pride of Madurai and the GI tagged ornamental and a biotherapeutic of the region, stands indeed a floral delight with manifold utility. Despite the vouching on its use in folk medicine and socio-cultural and economic interest conferred, the norms of its field cultivation, production and marketing have not been worked out in great detail. Notwithstanding to the popularity of this floral crop, there is research gap in understanding the dynamics of harvest. Attempts made to compare the efficacy of PGR treatments in this field study which involves foliar spraying of auxins, cytokinins, gibberellins and salicylic acid show that the flower development and yield is perhaps the first of its kind in Jasmine and can be considered useful for profitable manipulations. Experiments performed on randomized block design in the month of January - February for a period of two consecutive years indicate that among PGRs, GA and SA can trigger early flowering at higher intensities. Although each PGR used in the study could exert its own specific influence, salicylic acid treatments provided ample material for scrutiny. Best results of growth and yield could be observed at 100 ppm dosage where flower production was assessed in terms of increases in the number of flowering points, size of the individual flower and the quantum of the produce. Comparisons show that SA could increase the floral density by stimulating lateral shoots as in BAP and simulated the effects of GA by enhancing the enlargement of calyx and corolla whorls. Observations and results gathered in this investigation assume significance due to the paucity of documented information on this said species.
Keywords:
Salicylic acid, Foliar application, Jasminum sambac, Plant growth regulators, Shoot apical meristem, Flowering, harvest and yield

Abbreviations

BAP- 6-Benzylaminopurine;;CDL-Critical Day Length ; DW-Distilled Water; g – gram; GA_3-Gibberellic acid: Kg – Kilogram; NAA - Naphthalene acetic acid; PGR - Plant Growth Regulator; ppm- parts per million; RBD - Randomized Block Design; SA - Salicylic Acid;
SAM - Shoot Apical Meristem

1.1 Introduction

Jasmine is grown for its highly scented alluring flowers and it is among the most important floral crop of India. Past studies pursued in this ornamental presents the taxon as an enduring botanical with pharma interests. The plant is much valued for its exquisitely fragrant flowers, bitter, pungent and cooling nature and is used as a tonic to brain, purgative, and a cure for biliousness, itching sensation, and treatment for diseases of eye, ear, mouth and skin. Used in folk medicine, it allays fever, controls vomiting, and said to be used treatment of leprosy and ulcers. Vegetative and somatic tissue are used in traditionally in dealing with indolent ulcer, abdominal distension, diarrhoea, lowering the blood glucose level, regulating menstrual flow, and in cleaning kidney waste and eye inflammations. Much interestingly the plant is are galactogogues and therefore act as lactifuge, and as an antidiabetic, antitumor, anti-acne and antimicrobial agent and for the suppression of puerperal lactation (Shrivastav et al., 1988; Hongratanaworakit 2010; Rahman et al., 2011; Gowdhami and Rajalakshmi, 2015; Mourya et al., 2017).. With such pronounced reporting on its flower being used as antiseptic, aphrodisiac, sedative, expectorant and tonic (uterine) effects in ethnomedicine and is known to be widely cultivated as a principal crop.

Perfume extracted as Jasmine absolute is the most expensive fragrant oil and it takes about 8,000 hand-picked blossoms to extract 1 ml of its essential oil. Flowering in Jasmine starts from the sixth month or sometimes after planting, but the economic yield is generally viable from the second year. For the fresh flower, fully developed but unopened buds are picked in the early morning and the flower, as well as its fragrance, usually lasts for a day. Buds are picked at 5.00 to 6.30 am in the conditions prevailing here in this part of the country and farmers in Madurai make their livelihood entirely as a full-time vocation. They cultivate Jasmine taking pride in growing them owing to the lasting tradition and the socio-cultural significance attached with the flower and the DHAN foundation decided to facilitate the Jasmine farmers to organize and evolve Madurai Malli Farmers Association. Jasmine is grown extensively irrespective of the monetary gain which comes from the crop. The geographical indicator (GI) tag bestowed on this specific variety helps to sustain the market attention.

The specialty of the Madurai Malli is in its thick petals and the added fragrance than the other varieties. This feature helps to delay anthesis and serves well for the longer keeping quality (Lavanya et al., 2014). It has stiff and long petal that helps in easy garlanding in different styles and patterns ornamental and aesthetic preparations, decorations, and presentations. The sale price of the crop varies from Rs 70 to Rs.3000 INR per kg and the pricing differs depending on the season, and an average price of Rs.300 per kg is assumed for working out the breakeven. The yield of flowers per hectare in 2500-3000 kg and the cost is around Rs. 200 per kg (Jasmine cultivation project report, Farming economics, 2019). Once planted Jasmine can serve almost as a mini perennial with a span of 10 years of commercial longevity. Flowers are in good demand in the local market and a considerable amount of flowers are airlifted to Mumbai and exported to Gulf countries. Jasmine offers to industrial uses viz. essential oil extraction and cosmetic preparations.

Despite such dedicated attention given on growing Jasminum sambac as a commercial crop, there is hardly any literature support to the use of PGRs in the cultivation of this crop. Investigating the nutritional aspects and spraying Salicylic acid has been attempted in J. sambac where the results reported remain largely elusive (Al-Qubaie, 2013). Though a recommendation of a three-time application of 200 ppm of SA is made, it is still not clear if the substance can be treated as a PGR at such high dosage. By carrying out a field study on the use of SA on two commercial varieties of Mango, Singh and co-workers have shown that there had been a quantitative increase of growth up to a concentration of 2000 ppm and observed that doses of 4000mg l^{-1} are inhibitory (Singh, 2001). In early research, Hatayama and Takeno (2003) had demonstrated that the metabolic pathway from t-cinnamic acid to SA had been helpful in stress in induced flowering in certain species of Ipomea, synonymously referred as Pharbits nil. Though the utility of the classical PGRs on the cultivation of many ornamentals and crops is known and shown time and again (Basra, 2000), lack of such studies on Jasminum make the recommendation made in favour of using SA elusive and hence pitches for this study. This paper examines the influence of salicylic acid on the growth and development of Jasmine in comparison with three different classical PGRs.

1.2 Materials and Methods

This study was done with two year old Jasmine plants in the commercial plantation at Parampatti, a rural hamlet near the traditional Indian city Madurai in Tamil Nadu, India. The preliminary investigations were made during repeated field visits at different seasons of the year. Features of growth and development were assessed by a random count of 100 individuals in each of the marked source plant categories. As flowers were seen all round the year (at least sporadically) commercial harvest data was collected for 12 months from Jasmine growers. Flowers were collected as monthly harvest at the mature bud stage in the morning (05:00 hrs) was clubbed in calculating the bloom in four different quarters starting from the end of rainy season in November. Fixing a time interval of three months arbitrarily for each quarter, the extent of vegetative growth and flower production was assessed as per the indications given in the experimental trials.

Experiment: 1

Care was taken to undertake foliar spraying of the PGRs in accordance with procedures stipulated in agronomic studies. The primary intent of the first phase of study being centred on checking the efficacy of salicylic acid on Jasmine production, SA was administered as a foliar spray at 10 and 100 ppm, with only one round of application in each in 12 bush strong plots adequately separated by hedges of the similar dimensions all around. A power sprayer with a Nozzle flow rates at 2 bars was used uniformly in all cases. Spraying is done in the morning at 7.00 am for seven consecutive days from day 0 with a standard spray volume of 20 litres with the prefixed dose. Hormone free DW sprayed in the same way served as the control in this experiment. Monitoring growth changes each a day from day 1, incremental effects of the substance was evaluated first for a week with only floral yield assessed in terms of fresh weight of the produce.

Experiment: 2

Parallel studies were conducted at different plots to study the effects of SA in comparison with other plant hormones in a modified treatment procedure. Along with salicylic acid, at least one plant growth regulating substance representing each of the conventional PGR, NAA for auxin, BA for cytokinin, and GA_3 for Gibberrllins procured from Sigma and Lobo chemical suppliers was chosen for comparison at a time. Two sets of trials were tired in this field study following randomized complete block design (Yazdani, 2009). In the first set of trials focussing on solitary application of PGRs of 10 and 100 ppm concentrations to each experimental unit (each unit has 12 bushes). In the RBD, each experimental unit with treated plants were segregated and hedged with an equivalent numbers of bushes for cordoning of the given treatment that interferences between treatments is avoided. The effects of these treatments were checked and compared with equivalent concentrations of salicylic acid. Foliar spraying in this trial was done once in a week on successive Mondays for three times in all.

Growth and flower production were assessed in terms of the state of terminal and axillary buds, mean number of flowering points at the surface and the robustness of canopy (marked in terms of foliage density vs flower production). Trails made in triplicates helped in ascertaining the effects of PGRs and the evaluation is carried out at the end of the experimental period on Fridays, the fourth week from the time of first application. Since SA enabled many positive growth changes, the second set of trials was extended with two additional concentrations (1 and 1000 ppm levels). In addition attention was paid to assess synergistic or antagonistic influences. The effective dose of 100 ppm discerned from the previous trial was used as standard (control) in tests with co-supplementation of 10ppm dosage of the other three PGRs. Growth assessment were carried out concurrently in each experiment.

1.3 Results

Comparative data gathered from farmers coincided with the observations made at different seasons in the two consecutive years of study. It was found that the somatic growth overwhelmed during the rainy days and flower production was lean in this season and the immediate post-monsoon period (Table-1). Among the considered parameters, flowering was in prime focus, although the general attributes of growth provided for the back drop of this study. Yield data in this floral crop clearly shows despite stray flowering, profitable yield was in the offing only form the second quarter of the calendar year onwards. It could be noticed that the harvest could go up seven times more that what is attained in the winter months. With the climate getting warmer, vegetative growth started slowing down gradually and there was a concomitant increase in flower production.

Yield increase can be correlated well with an increase in the number of flower picking points available at the surface of the canopy. During peak flowering, jasmine shrubs sported serene white floral bloom in attractive cymes. Flower production surged in the month in February and March at Madurai conditions. It is interesting to note that unlike many other ornamental floral crops, Jasmine (J. sambac L.) is seen prominently with flowers in the mid-summer. From the two successive sets of trials carried out n the month of February, (i) solitary application of salicylic acid (SA) made in comparison with similar doses of classical plant regulating substances namely an auxin (NAA), gibberellic acid (GA_3), and cytokinin (BA) and (ii) the target compound SA combined with selected doses of the latter, it could be learnt that the PGRs can be implicated for interesting growth changes.

In the exclusive study where SA was administered as a foliar spray every day, only once a day in the morning, for seven consecutive days from day 0 with a standard spray volume of 20 litres with prefixed concentrations, SA triggered growth changes that were as effective as conventional hormones. In the comparative study where similar one-time-a-day spraying was done in the 0 day, 7^{th} day and the 14^{th} day (a total of three time application is done), PGRs exerted their own characteristic influence in mediating growth and development (Table-A.2). An assessment of growth and development done on the 28^{th} day since the first application showed that traits such as plant height, flower picking surface area per plant, length of a flower bearing branch, number of leaves in such emergent shoots, leaf area of a fully expanded leaf, and the size and intensity of flower production differed markedly from plants assessed in control (the group of plants fed only with distilled water).

As NAA applications altered these responses positively but with lesser consistency, GA_3 exerted in prominent growth stimulation on vegetative shoot growth and flower production. Somatic shoots in both doses of the PGR (10 and 100 ppm) facilitated shoot elongation with marked intermodal extension. The extent of growth in the said treatment was so pronounced that the contour of flat flower picking surface in the PGR free control is modified into widely spaced and well spread broadened canopy surface in GA_3 treatments. Conversely, plants groomed in plots sprayed with BA and SA remained far more compact and dome-shaped. With a quantitative increase in BA concentrations, the nodal buds in the axillary region emerged into active shoots with most shoot tips turning into mantle forming floral receptacles. The shorter internodes of the primary shoot axis combined with active elongation of axillary shoots presented the plants condensed and robust in this treatment.

Though flowering at outward appearance looked sparse, flower production was enhanced in terms of the number of floral receptacles formed in each plant in GA treatments. Shoot apices ending up in complex cymes with relatively smaller flowers adorned the plants quite discretely in NAA treatments. Unlike in gibberellic acid applications where the individual flowers were larger but fewer in numbers, BA and SA treated plants stepped up flower production per se in terms of the floral count. When compared with the established PGRs, salicylic acid reeled out much more interesting and noteworthy results. When advocated as foliar spray salicylic acid at 10 and 100 ppm promoted both shoot growth and flowering as well. The positive growth stimulus that this particular substance evoked can be inferred from the elongation of shoots resulting in dome shaped canopy. Active differentiation of axillary shoots leading to flower buds could be noticed both at the surface and lower echelons. SA-induced increase in floral density can be inferred from an increase in the number of flower producing receptacles, and the enlargement of individual flowers as well.

Studies on SA treatments extended to two additional dosages (1 and 1000 ppm levels) and the trials where the substance is checked for its functions in combination with NAA, BA and GA_3 fetched additional insights (Table-3). The lower and higher doses proved inadequate and toxic respectively. As 1000 ppm concentrations elicited clear signs of growth retardation, the 100 ppm dosage supplied along with BA and GA_3 (both used as an adjuvant separately alongside SA at 10 ppm) turned out favourable results. In contrast to the morphometric traits evoked in individual supplementations of BA at an equivalent concentration, SA-BA duo sported a visible increase size of an individual flower. In contrast to the number of flowering point noticed individually in 10 ppm GA_3, SA and GA_3 formed as floral receptacles emerged at a greater frequency in the latter.

The earlier strategy of providing a SA sprays from Day 0 to day 6 continuously and incrementally with DW as control provided further clues. Data depicted in figure-1 shows that the control plants offered a steady yield unperturbed throughout the seven day period of study. As opposed to this SA treatment of 10 and 100 ppm doses showed an increase that peaked on day 3 only to decline gradually to flatten production on day 7. Between the two concentrations, 100 ppm showed a substantial rise in the first three days of applications while the 10 ppm level could sustain the favourable influence on enhancing the size and weight of the produce for a longer period of time. In terms of the quantum of yield, the higher dose of 100 ppm contributed to a higher yield.

1.4 Discussion

This study taken up to collect information on the dynamics of Jasmine cultivation showed that the shoot apical meristem (SAM) which serves as an important instrument of adjustments. It appears that Madurai malli or Gundu Malli, the shrubby short term perennial, once planted is able to offer produce for 7 to 10 years primarily by the tacit changes bought about in the functioning of the shoot meristem. The meristem active in the terminal bud during and in the immediate post monsoon period contributes more to somatic growth. As a crop the plants are groomed by mechanical dressing and pruning and the routine picking of flowers, a larger table for the harvest of the flower is created at a height of 4 feet up from the ground and in this process, the SAM activity is inadvertently modified and mediated to keep the plant stay in the rejuvenated state (Rao and Rout, 2003).

1.4.1 Flowering in Jasmine

Changes in the functions of the growing region in different seasons of the year bring the variations in the growth characteristics and yield at different seasons of the year. As shown in flag leaf physiology of certain other species, signals received from the environment may cause the transition and the transformation of the vegetative shoot bud into reproductive structures (Zhang et al., 2007). Data presented in Table- A.1 depicts Jasmine as a summer crop where floral evocation appears to commence with the warming of ambient temperature. Convincing increases in yield and active flower production commencing in the second quarter month of February with continued production stretching into the third quarter show the species to be photo-periodically active implicating it to be a long day plant.

This particular variety of Jasmine which is not hampered by the summer showers in its floral output hints at a mechanism of flowering which is more light controlled rather a being temperature mediated. Floral biologists have shown that CDL (critical day length) is crucial in photoperiodic species in the elicitation of the flowering response (Serçe and Hancock, 2005). That J. sambac clearly presents a hike in flowering the month of February with increasing in conditions of day length and shows a contentious fall in the months after June and July, past June 21 the longest day of the year intervening the end of the third quarter, suggests that phytochrome mediated mechanism could function in controlling the flowering in Jasmine. Though the drying of soil is compensated by irrigation and subsequently rains, Jasmine growers maintain that the fourth quarter, months commencing from August to the end of the year is a lean period for the crop.

1.4.2 SAM Conversions

Though flowers of Jasmine appear in all months, warmer and arid conditions appear to influence a favourable shift of SAM into flowering mode. As may be inferred from the flower picking schedules standardized in Madurai conditions, blooming of flowers and vegetative flushes appears alternately in cycles. In a commercial garden, flowers are picked manually daily basis for seven days after which a resting period of three weeks of recuperation is allowed. It could be possible that the intermittent spacing facilitate the plant to reequip itself with carbon reserves and assimilatory capabilities that the fresh bloom comes a new with larger flowers. The produce in this species is the flower bud which usually picked at the pre-balloon stage referred to as Mottu in the local language which is yet to emanate its fragrance.

1.4.3 Exogenous PGRs modify growth attributes in Jasminum sambas L.

In the present results, growth-regulating substances show that the Madurai variety of Jasmine can respond to the externally applied hormones and Salicylic acid. With Gibberellins conferred with the ability to promote seed germination (Oh et al., 2006), stem elongation, especially the intermodal extension (Suge 1985), flowering (Bao et al., 2020), leaf and fruit senescence (Amorim et al, 2017), the steroidal compound elicited many of these said influences in the present study. Owing to the clear indications seen in GA_3 treatments on the elongation shoots, expansion of leaves and enlargement of flowers it can be said without any ambiguity that foliar applications of Gibberellins can be advantageous. That plants treated with GA_3 had the advantage to put forth flowers that are prominent, larger, and heavy is an observation of commercial overtone with its own academic significance.

Implying that the said PGR can substitute long day conditions (Rademacher, 2018) and offer provisions to tolerate stress (Sharan et al., 2017) can be an additional deduction made from the data presented in Table-A.2. In simulating a photoperiodic response, GA_3 with a potential to enhance yield in terms of weight gained in individual flowers stepped up the formation of flowers in greater number of side shoots. Axillary branches as characterized in this study and previous investigations on cytokinin (Froschle et al., 2017) could be seen as a benefit of SA application. Since cytokinin can promote cell division and determine cell differentiation in conjunction with auxins (Müller et al., 2017), the PGRs had received favourable commendations from horticulturists. Nevertheless the highpoint discussed for advocating cytokinin use in ornamentals is that it is has the ability to defer senescence, sustain and support flower production (Santoso et al., 2019). Since both BA and SA could reveal this in solitary applications and in combined treatments, it is possible that the mechanisms underlying these processes in Jasmine in the present context could be complementary.

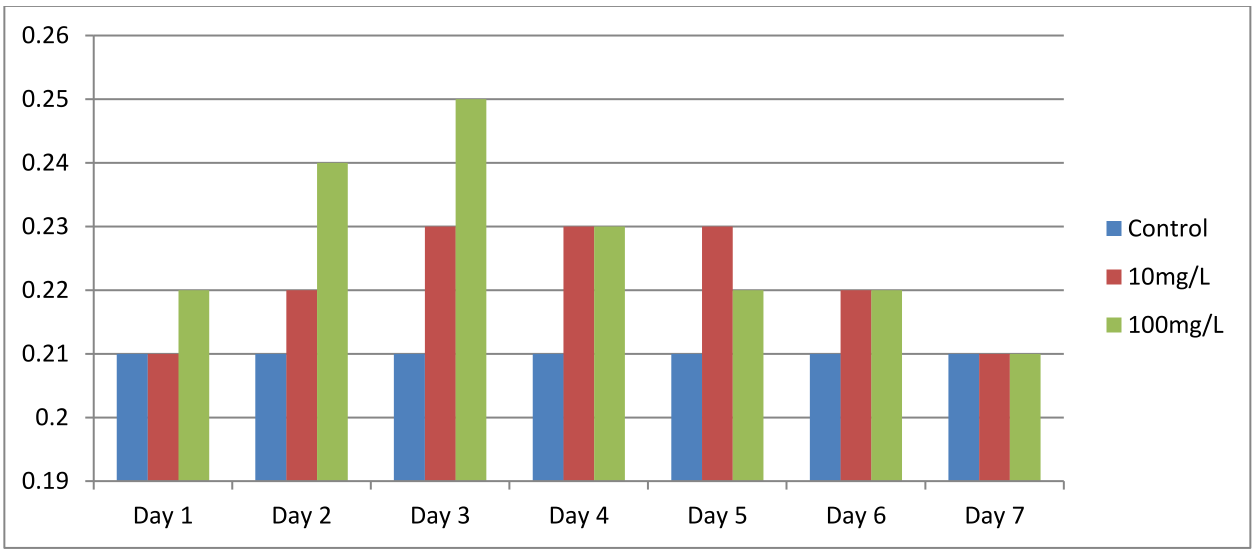
1.4.4 SA exerts favourable influences

Even though the use of NAA as a supplement in the foliar spray had not been as convincing as other PGRs, there are indications to suggest that auxins can cause apical dominance (Balla et al., 2016), active tropisms (Zhang and Friml 2020), induction of cambial divisions leading to the hardening and sclerification of the frame and induce rooting (Van Overbeek, 1959). It is feasible that more focussed investigations on these aspects in the commercial cultivation of J. sambac may find greater relevance. Though studies on the use of salicylic acid in the field have been taken up by Al-Qubaie, 2013 and Singh et al., 2001, researchers who were recommending the use of SA have only been insisting upon further studies to confirm its hormonal properties. Known to be synthesized in plants from trans-cinnammic acid by way of a side branch of the phenylpropanoid pathway, SA is better recognized for its thermogenic properties and role in disease resistance (Raskin, 1962).

The literature on its ability to trigger flowers has been mostly published from aquatic weeds and reports on land plant are sparse (Khurana and Maheshwari, 1980). The threshold of SA used in the field is shown to be quite high (Al-Qubaie, 2013). It is in this pretext that the results presented in Figure-A.1 and Table- A.3 attracts attention. In a situation where concentration up to 2000 ppm is advocated (Singh et al., 2001) and a three time repeated application of 200 ppm of SA for field application is recommended (Al-Qubaie, 2013), focussed and pointed foliar spraying of the substance has been seen with retarding effect at 1000 ppm. Though the compound has been growth-stimulating as claimed in past (Raskin, 1992), the cumulative and incremental effect that SA had evoked on a daily spraying experiment suggestive enough to be both growth promotive and inhibiting depending on the concentration. That PGR by definition can enhance a certain response shall inhibit it beyond the threshold serves well to explain this situation. Since jasmine plants respond to SA treatments in opposing terms based on a quantitative interaction, it could be suggested that salicylic acid could be hormonal in action.

Figure A.1: Increment in yield gained after Salicylic acid application.

(Request colour printing of this figure that the contrast between treatments will be explicitly depicted)



Y- axis represents yield / harvest in weight of a single flower on an average (given in g., each day), and the X-axis day of harvest after SA application.

1.5 Appendices

Table- A.1 Flowering patterns during the different seasons of the year.

S. No	Quarter	Months	Vegetative Growth	Flowering	Yield/ Plant (in g)
1	I	November-January	+++	+	21.59
2	II	February-April	++	+++	145.49
3	III	May- July	++	++++	165.73
4	IV	August - October	+	++	101.55

Vegetative Growth: But for stray flowering bushes are in somatic phase with spread out leaves and active terminal shoots given as flower bud (Fb) to shoot tip (St) ratio : +++ ST(80): Fb (20); ++ST(60): Fb (40) ; +Shoot tips dormant and the flower buds sparse and condensed. **Flowering**: Intensity of flowering shown in terms of flower bud (Fb) to shoot tip (St) ratio: + ST(80): Fb(20); ++ ST(40); Fb (60); +++ ST(80): Fb (20) ;+++ ST(80): Fb (20) ; ++++ almost all shoot terminals converted into flower.

Table: A.2 Growth responses to foliar sprays of PGRs at selected concentrations

Treatments (PGRs in ppm)		Plant Height (in inch)	Branching	Flower Picking Surface		MSL (cm)	MN/ fl. shoot	LLI (in cm)	LA (l×b) (in cm)	SSA (State of Shoot Apex)	FD (Floral Density)
				Dia in inch	Den-sity						
Distilled Water (control)		24.3 ± 2.03	8.4 ± 2.13	F ; 22.6± 1.67	+	15.2 ± 0.93	4.3 ± 1.26	2.2 ± 0.47	4.2x 3.3	'a+'	40% ST into flowers
NAA	10	27.3 ± 2.25 (12.35)	9.3 ± 1.66 (10.71)	F ; 23± 3.23 (1.77)	+	15.9 ± 1.37 (4.60)	4.7 ± 1.31 (9.3)	2.5 ± 0..96 (13.67)	4.7× 3.1	'a+'	Moderate l increase in flowering
	100	28.7 ± 2.17 (18.11)	10.1 ± 1.9 (20.24)	F; 24± 2.89 (6.19)	+	16.8 ± 2.1 (11.22)	5.2 ± 2.11 (20.93)	2.7 ± 1.3 (22.73)	5.1× 3.9	'd'	Flower buds small, at increased inumbers but dormant.
BAP	10	23.7 ± 2.2 (-2.47)	9.71 ± 1.83 (15.59)	F; 25± 1.77 ±2.3 (10.62)	++	14.9 ±1.8 (-1.9)	5.2 ± 1.83 (20.93)	2.4 ± 1.1 (9.09)	4.3× 3.9	'f+'; as in control'	Increase with a increase in number of flowering shoots appearing at nodes
	1	22.	11.	D;	+	14.	5.3	2.3	4.5×	'f++';	50% increase in

	00	7 ±1.92 (-6.58)	3 ±2.13 (34.52)	24.9 ±2.22 (10.18)	++	7 ±2.6 (-3.2)	±1.96 (23.2)	±1.26 (4.55)	4.0	Condensed flowers	flowering at active ax. shoots.
GA_3	10	30.7 ±1.56 (26.34)	8.9 ±1.66 (5.95)	BS; 37±1.93 (63.72)	+	29.7 ±2.9 (95.3)	5.7 ±1.33 (32.5)	4.9 ±1.36 (122.7)	6.6×5.8	'a++'; Flowers prominent	Flowers in simple to secondary cyme
	100	33.3 .±2.07 (37.04)	8.6 ±1.23 (2.38)	BS; ±35.5 1.87 (54.87)	+	34.2 ±2.1 (125)	6.2 ±1.76 (44.18)	5.2 ±1.67 (136.63)	7.9×6.2	'a++'; Flowers prominent	Secondary cyme with large flowers
SA	10	26.0 ±1.69 (6.99)	10.3 ±1.03 (22.62)	D;27±2.22 (19.47)	++	21.6 ± 0.96 (42.11)	4.9 ± 1.07 (13.95)	2.8 ± 0.96 (27.27)	5.9×4.3	'f++'; Increased Floral density	Up to 70 % increase in flowers, in complex cyme
	100	29.7 ±2.13 (22.2)	10.9 ±1.96 (29.76)	D;28.0 ± 1.33 (23.89)	++	22.3 ±1.67 (46.71)	6.3 ±1.96 (46.51)	3.2 ±1.03 (45.45)	6.1×4.9	'f+++'; Higher Floral Intensity	Over 70 % shoots with high floral density

*Figures in parentheses indicate percent increase/decrease from that of control.

Plant Height: Given in inches from ground level to the canopy; **Branching**: Only dominant sclerified lead shoots are taken into consideration.; **Flower picking surface**: **F** –flat; **D**- Dome-shaped and dense: **BS**- branched and spread out due to active elongation of shoots (numbers indicate the extent of spread in diameter); **MSL**: Mean Shoot Length of floral branch terminating in a prominent white balloon-shaped flower buds, given in centimetre; .**MNN:** Mean number of nodes in flowering shoot as counted in terms of the number of leaf pairs found from the branching point to the end of the receptacle bearing the cyme; **LLI:** Length of the longest internode in the considered flowering branch; **LA:** Leaf Area measured in the largest leaf present in a floral branch furnished as lxb dimensions; **SSA:** State of shoot apices as seen in a vegetative state of growth (a+ and a++ based on the length of the shoot bud indicating moderate growth and active bud) While 'd' indicates dormant buds, f+, f++ & f++ marked as flower buds as scant, moderate, and intense flower production counted as the number of flowering points counted in random samples, respectively; **FD:** Floral Density based on number cymes in a given floral receptacle examined in each treatment. '-' Poor; + Scant; '++'Moderate; '+++'Intense.

Table: A.3 Influence of Salicylic acid on flowering in Jasminum sambac, the GI crop of Madurai

PGR treatments (ppm)		**Plant Height (in inch)**	**Flower Picking Surface (in inch)**	**MSL in a floral branch (cm)**	**MNN (Mean number of node/ flowering shoot)**	**LLI (Length of the longest internode (in cm)**	**LA (Leaf area, in terms of l×b) (in cm)**	**SSA (State of Shoot Apex))**	**IoF (Intensity of Flowering)**
SA	0	24.3 ±2.03	F ; 22.6 ±1.67	15.2 ±0.93	4.3 ±1.26	2.2 ±0.47	4.2x3.3	'a+'	40% Shoot tips forms flowers
	1	24.7 ±2.13 (1.65)	F ; 23.6 ±1.67 (4.42)	15.9 ±1.63 (4.61)	4.4 ±1.26 (4.35)	2.6 ±0.47 (18.18)	4.7×3.4	f+	++ Flowers are prominent In simple Cyme
	100	29.7 ±2.13 (22.2)	D;28.0 ±1.33 (23.89)	22.3 ±1.67 (46.71)	6.3 ± 1.96 (46.51)	3.2 ± 1.03 (54.54)	6.1×4.9	'f+++'; Higher Floral Intensity	+++ Complex Cyme
	1000	17.6 ± 1.31 (-27.57)	F ; 16.6 ±1.2 (-26.54)	14.3 ±1.96 (-5.92)	4.2 ±1.47 (-2.36)	2.4 ±0.25 (8.70)	3.3×2.7	D	+ Repressed and ondensed flower
SA 100 + NAA 10		27.3 ±2.22 (12.34)	F; 22.7 ±2.89 (0.44)	17.3 ±1.27 (13.82)	5.5 ±1.53 (27.91)	3.6 ±1.3 (63.64)	6.8×4.1	cf	+ Complex Cyme
SA 100 + BAP 10		26.1 ±1.92 (7.41)	D; 24.9 ±2.13 (10.18)	19.6 ±1.23 (28.95)	6.9 ±1.96 (60.4)	3.0 ±.26 (34.78)	6.2×5.4	f+	+ Larger complex Cyme but flowers less in number
SA 100 + GA_3 10		32.6 ±1.56	BS;29.1 ±1.33	23.4 ±1.33 (53.9	7.1 ±2.13 (67.44	5.1 ± 1.33 (131.82)	9.7×6.2	f+++	+++ Complex Cyme in almost every

	(34. 16)	(29.20)	5)	)				node

*Figures in parentheses indicate percent increase/decrease from that of control.

Plant Height: Given in inches from ground level to the canopy; **Branching**: only dominant sclerified lead shoots are taken into consideration; **Flower picking surface**: **F** –flat; **D-** Dome shaped and dense: **B-** branched out due to active elongation of shoots; **MSL**: Mean Shoot Length of floral branch terminating in prominent white balloon shaped flower buds; **MN:** Mean number of node in the flowering shoot as counted in terms of the number of leaf pairs in floral receptacle terming in a Cyme; **LLI:** Length of the longest internode in flowering branch**. LA:** Leaf area as measured in the largest leaf present in a floral branch; **SSA :** State of Shoot Apex where 'd' indicates dormant f+, f++ & f++ marked as flower buds as scant, moderate and intense respectively. cf denotes condensed flower.; **IoF**: Intensity of floral receptacle shown as '-' Poor; '+ 'Scant;' ++' moderate; '+++'intense.

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The authors report no declarations of competing or conflicting interest.

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