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Research Article

Response of flower quality and physiological characters of *Jasminum sambac* (L.) to modified planting system and pruning schedule

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Abstract
Increasing planting density in *Jasminum sambac* (L.) is a recent trend among farmers and an effective strategy for improving flower productivity without affecting the standard of flower buds. This study aimed to establish the effect of varied plant density with different pruning levels on the flower quality during off, peak and lean seasons in *J. sambac* during 2021-'22. The treatments comprised of four levels of plant density *viz.*, D_1- one plant pit^{-1} (control), D_2 - two plants pit^{-1}, D_3 - three plants pit^{-1}, D_4 - four plants pit^{-1} and two levels of pruning viz., P_1 - one pruning year^{-1}(control), P_2 - two prunings year^{-1}. The trial was laid out in Factorial Randomized Block Design (FRBD) with three replications. The important traits on flower quality parameters namely the total length of the flower bud, length of the flower bud without corolla tube and corolla tube length, were influenced significantly ($P<0.05$) by three plants pit^{-1} (D_3) and two prunings year^{-1} (P_2). But there was no interaction effect between plant density and pruning frequency for these flower quality parameters. The interaction effect was also significantly ($P<0.05$) influenced by the physiological and biochemical traits, namely chlorophyll content, total phenol content, soluble protein and Indole Acetic Acid (IAA) oxidase activity. The pooled analysis data of the treatment T_6 (D_3P_2) was found superior due to increased plant density combined with alteration in pruning. This performed better with enhanced number of new shoots and produced good quality flower buds through enhancement of physiological activity in all three seasons (off, peak and lean) when compared to conventional planting T_1 (D_1P_1) method.

Keywords: Flower quality Jasmine, Planting density, Pruning level, Physiological characters

INTRODUCTION

Jasmine is one of the strongly reminiscent flowers in high demand in the markets during festival seasons because it is esteemed for its attractive redolent flower strings called *veni.* It is also widely used for garland making, floral decorations, the production of perfumes, cosmetics, *etc*. Jasmine significantly contributes to the national economy of India, where Tamil Nadu cultivating a considerably larger area. Tamil Nadu ranks first in production particularly in Madurai district, with an area of 1,250 hectares with an average productivity of 7.85 tonnes per hectare (National Horticulture Board 2020-2021) compared to other states in India. The peak flowering period is from March to June (Peak season), where it flowers abundantly, leading to a glut of Jasmine flowers pushing down the price. The prices peak from July to October (Lean season) since this period is packed with religious festivals. During November to February (Off season), the arrival of *Jasminm sambac* flowers in the market is very meagre and the quality of the flowers also declines because of the wide temperature fluctuations occurring in this season, resulting in exorbitant prices. Su and wang (2001) reported that single-whorled cultivars of *J. sambac* undergo ultra structural cellular changes when exposed to low winter temperature. Hence, mechanical flower forcing called 'pruning' will be attempted in Jasmine which helps in utilization of nutrient sources by elimination of unwanted shoots and triggering sprouting of dormant buds (Pawar *et al*., 2019; Khanchana and Jawaharlal, 2019). Pruning practice during winter months has proved to facilitate higher prices in the market, thereby increasing the profitability to farmers (Kalaimani *et al*., 2017). In *Bougainvillea glabra* the different pruning styles modified the root and shoot initiation, which ultimately affects the physiological and chemical traits (Saifuddin *et al*., 2010). Keeping this in mind, this study focused on inducing a continuous and uniform supply of flowers almost annually by increasing the number of plants per pit by adopting a modified planting system so that the secondary branches obviously multiply and rapidly attain adequate and favourable canopy spread. This technology is a new concept, and available literature related to this idea is very scanty. In the present study, the combined effect of modified planting system and pruning levels on the number of flowering shoots per plant was studied based on the flowering physiology in response to different seasons. Efforts have been made to improve and standardize the planting density in Jasmine with the ultimate objective of inducing continuous flowering without affecting the quality of flowers and thus maximizing the returns, compared to the conventional planting system.

MATERIALS AND METHODS

The experiment was conducted from January 2021 to November 2022 at the Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experiment was arranged in a Factorial Randomized Block Design (FRBD) with three replications. The first factor consisted of four plant density levels (D_1, D_2, D_3 and D_4) and the second one consisted of two levels of prunings year^{-1} (P_1 and P_2). One pruning year^{-1} was done in November as per the recommended package of practices (conventional method) and two prunings year^{-1} were done in November and May. The details of treatment notations used in the experiment were as follows (Table 1).

The new *J. sambac* clone (Acc. Js-36) has been evolved by the Department of Floriculture and Landscape Architecture of Tamil Nadu Agricultural University, Coimbatore called 'Nine Budded Gundumalli' (Fig. 1) was involved in the present study which is a genetically distinct type with a greater number of nine-budded cymes per plant which is prolific and high yielder compared to the standard variety Ramanathapuram Gundumalli. Rooted plants were planted in the main field at a spacing of 1.2 x 1.2 m at four different plant densities per pit, namely, one plant pit^{-1}, two plants pit^{-1}, three plants pit^{-1} and four plants pit^{-1}. After one year of planting, the pruning operation was initiated and the plants were pruned in the last week of November 2021 and May 2022 to a height of 50 cm from the ground level. After the pruning operation, Farm Yard Manure (FYM) and chemical fertilizers (NPK) were applied at 100% RDF for one plant pit^{-1} and 125% increased dosage for two, three and four plants pit^{-1}. Other cultural operations *viz.,* weeding, irrigation, pest control, micronutrient spray *etc*. were taken up as per the recommendations of the Crop Production Guide of TNAU and the Tamil Nadu State Department of Horticulture and Plantation Crop.

The pruned plants were observed regularly, and the data was recorded for one year (2021-2022) for the flower quality parameters viz., the total length of the flower bud (cm), length of flower bud (without corolla tube) (cm), corolla tube length (cm), flower bud width (cm) and the diameter of opened flower (cm) (Fig. 2). The physiological and biochemical parameters including chlorophyll content (SPAD value), total phenol content (mg g^{-1}), soluble protein (mg g^{-1}) and Indole-3-acetic Acid (IAA) oxidase activity (µg of unoxidised auxin g^{-1} h^{-1}) were analyzed in the fully expanded leaf (third leaf from the growing tip) at specified phenophases in five randomly selected plants that were tagged per replication in each treatment and observations were recorded. Plant growth, yield and physico-chemical attributes are important parameters to study the variability and also to improve the yield and quality among the different crops (Patel *et al*., 2011). For the chlorophyll content, SPAD meter readings were taken as per the

Table 1. Description of treatments

Treatments	Description
T1 (D1 P1) Control	One plant pit^{-1} + One pruning year^{-1}
T2 (D1P2)	One plant pit^{-1} + Two prunings year^{-1}
T3 (D2P1)	Two plants pit^{-1} + One pruning year^{-1}
T4 (D2P2)	Two plants pit^{-1} + Two prunings year^{-1}
T5 (D3P1)	Three plants pit^{-1} + One pruning year^{-1}
T6 (D3P2)	Three plants pit^{-1} + Two prunings year^{-1}
T7 (D4P1)	Four plants pit^{-1} + One pruning year^{-1}
T8 (D4P1)	Four plants pit^{-1} + Two prunings year^{-1}

method described by Peng *et al*. (1996) using a chlorophyll meter (SPAD-502) designed by the Soil Plant Analysis Development (SPAD) section, Minolta Camera Co., Ltd., Japan. The total phenol content was estimated by Folin Ciocalteau method and Catechol was used as a standard (Malik and Singh, 1980). The soluble protein content was estimated with tricarboxylic acid extract from leaf sample following the method of Lowry *et al*. (1951). The IAA oxidase activity in the leaf sample was determined colorimetrically at 540nm as p er the method of Parthasarathi *et al*. (1970). The OD values were referred to a standard curve using auxin (IAA – 10 to 100 µg l^{-1}).

Statistical analysis

The R statistical package (Version 4.2.1) downloaded from http://cran.r project.org was used to perform data analysis. The Doebioresearch package was used for the analysis of Factorial Randomized Block Design (FRBD) for 2 factors. This function gives ANOVA, Shapiro - Wilk normality test (p-value) of residuals, SEd (standard error of difference), CD (critical difference) P=5%, interpretation of ANOVA results and multiple comparison test (LSD test) for means.

RESULTS AND DISCUSSION

Flower quality characters

The present study revealed that the flower quality parameters *viz.*, the total length of the flower bud, length of a flower bud (without corolla tube), corolla tube length, flower bud width and diameter of the opened flowers were influenced non-significantly ($P>0.05$) due to the interaction effect among all the different treatments in off, peak and lean seasons. However, the plant density and pruning frequency had a significant ($P<0.05$) effect on all the flower quality parameters. The highest mean values for the flower quality parameters during the off, peak and lean seasons were recorded in the treatment T_6 involving 3 plants pit^{-1} and 2 prunings $year^{-1}$. The values recorded in this treatment (off, peak and lean seasons) respectively were the total length of the flower bud (2.16 and 2.14 cm), (3.00 and 2.95 cm) and (2.61 and 2.56 cm), the length of the flower bud without corolla tube (1.19 and 1.19 cm), (1.54 and 1.52 cm) and (1.47 and 1.44 cm) (Table 2), corolla tube length (0.97 and 0.95 cm), (1.46 and 1.43 cm) and (1.13 and 1.11 cm), flower bud width (0.83 and 0.80 cm), (1.15 and 1.11 cm) and (0.99 and 0.97 cm) (Table 3) and diameter of opened flower (2.49 and 2.45 cm), (3.69 and 3.64 cm) and (3.01 and 2.98 cm) respectively (Fig. 3).

Factors like climate, soil, cultural manipulations and interactions considerably influence plant growth and flower quality. Pruning time and pruning level also play a prime role in deciding the size of the flower buds, as reflected by the width and length of the bud. Gibson (1984) and Anderson (1991) reported that pruning influences flower quality and increases flower size along with vigour of Jasmine plant. Khattak *et al.* (2011) also obtained larger flower size due to better vegetative growth, congenial climatic condition and a large quantity of reserve food production due to pruning time in Rose (*Rosa hybrida* L.). Thus, the increased availability of photosynthates due to enhanced vegetative growth of a plant which might have been diverted to the sink and utilized for the production of better quality of Jasmine flowers, which conforms with the earlier findings of Ghulam *et al.* (2004) for *Rosa* sp., Porwal *et al.* (2002) for *Rosa damascena*, Kalaimani *et al.* (2017) for *J. sambac,* Nair *et al.* (2009) for *J. sambac,* Adnan *et al.* (2013) for *Rosa centifolia;* and Lokhande *et al.*

Fig. 1. *New clone 'Nine Budded Gundumalli'*

Fig. 2. *Flower quality parameters*

(2015) for *J. sambac*. The present investigation also supports the earlier observation of Singh *et al*. (2020) that quality parameters in guava (*Psidium guajava* L.) were significantly influenced by planting system and planting density. They reported that the highest fruit length and width respectively, were produced in the Square system of planting (6.61 cm and 6.99 cm) followed by the Hedge row system (6.55 cm and 6.97 cm). These results are also in agreement with the findings of Kumar *et al*. (2015) in fig (*Ficus carica* L.) and Wu *et al.* (2020) in perilla sprouts (*Perilla friesians* L.).

Physiological and biochemical characters

The physiological and biochemical traits *viz*., chlorophyll content, total phenol content, soluble protein and IAA oxidase activity were found to be significantly ($P<0.05$) influenced by plant density, pruning levels and their interaction effect (Table 4 and Fig. 4).

The chlorophyll index (47.71, 45.59 and 50.60 SPAD value), total phenol content (2.31, 2.13 and 2.74 mg g^{-1}), soluble protein content (12.06, 11.65 and 12.57 mg g^{-1}) and IAA oxidase activity (14.91, 14.37 and 15.44 µg g^{-1} h^{-1}) were also influenced significantly by the plant density, pruning levels and their interactions respectively. Thus, it could be noticed in the present study that plant density, pruning levels and their interaction effect significantly and positively influenced the physiological and biochemical traits of *J. sambac*. After pruning, the highest level of chlorophyll, total phenol content, soluble protein content and IAA oxidase increased gradually with the increase in the age of leaf and became static after the maturity of the leaves. A similar trend of change in chlorophyll content with the maturity of leaves has also been reported by Raj *et al*. (2021) in litchi (*Litchi chinensis* Sonn.). Severely pruned trees of mango (*Mangifera indica* L.) grown under high-density planting had the highest content of chlorophyll, total sugars (TS) and polyphenol oxidase (PPO) activities. In contrast, lightly pruned trees had the highest reducing sugars (RS) content. Moderate pruning intensity significantly increased total phenolics (TP) contents than non-pruned trees (Singh *et al*., 2010). These results also agree with those of Kaushik *et al.* (2020) in peach (*Prunus persica* Batsch).

The present investigation also supports the earlier observation that frequent pruning of *Bougainvillea glabra*

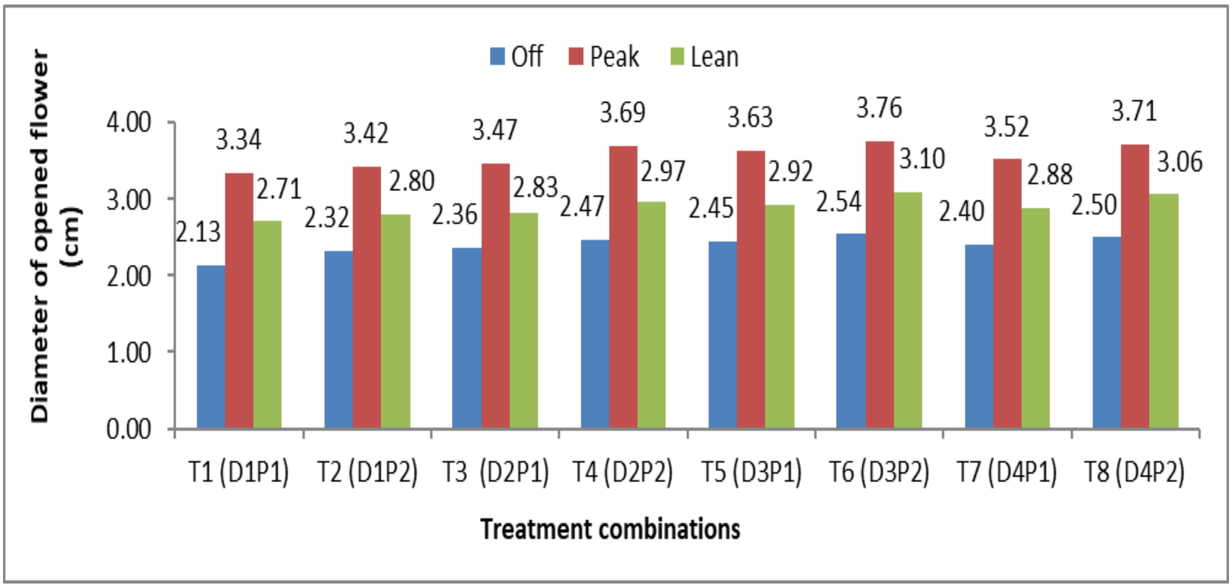

Fig. 3. *Influence of planting density and pruning schedule on diameter of opened flower (cm) in J. sambac*

Table 2. Influence of planting density and pruning schedule on the total length of the flower bud and length of flower bud without corolla tube in comparison with conventional planting in *J. sambac*

Treatment	Total length of the flower bud (cm)									Length of flower bud (without corolla tube) (cm)								
	Off season			Peak season			Lean season			Off season			Peak season			Lean season		
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	1.80	1.99	1.89	2.70	2.78	2.74	2.30	2.41	2.35	1.01	1.09	1.05	1.40	1.46	1.43	1.30	1.36	1.33
D_2	2.01	2.16	2.08	2.80	2.80	2.89	2.45	2.59	2.52	1.10	1.20	1.15	1.47	1.53	1.50	1.38	1.46	1.42
D_3	2.10	2.23	2.16	2.99	3.04	3.00	2.57	2.65	2.61	1.15	1.24	1.19	1.52	1.56	1.54	1.45	1.50	1.47
D_4	2.05	2.20	2.12	2.89	3.02	2.95	2.53	2.61	2.57	1.12	1.23	1.17	1.50	1.55	1.52	1.43	1.47	1.45
Mean	1.99	2.14		2.84	2.95		2.46	2.56		1.09	1.19		1.47	1.52		1.39	1.44	
	D	P	D × P	D	P	D×P	D	P	D×P	D	P	D×P	D	P	D×P	D	P	D×P
SEd	0.026	0.018	0.036	0.042	0.030	0.060	0.041	0.029	0.058	0.014	0.010	0.020	0.021	0.015	0.030	0.019	0.013	0.027
CD (P=0.05)	0.056	0.039	0.079	0.091	0.064	0.128	0.088	0.062	0.125	0.030	0.021	0.043	0.045	0.032	0.064	0.041	0.029	0.058
p-value	0.649			0.038			0.879			0.324			0.589			0.158		

*D_1 – One plant pit^{-1}, D_2 – Two plants pit^{-1}, D_3 – Three plants pit^{-1} and D_4 - Four plants pit^{-1}; *P_1 – One pruning year^{-1} and P_2 – Two prunings year^{-1}

Table 3. Influence of planting density and pruning schedule on corolla tube length and width of flower bud in comparison with conventional planting in *J. sambac*

Treatment	Corolla tube length (cm)									Flower bud width (cm)								
	Off season			Peak season			Lean season			Off season			Peak season			Lean season		
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P^2	Mean
D_1	0.79	0.90	0.84	1.30	1.32	1.31	1.00	1.05	1.02	0.61	0.67	0.64	0.94	0.98	0.96	0.82	0.86	0.84
D_2	0.91	0.96	0.93	1.33	1.46	139	1.07	1.13	1.10	0.69	0.82	0.75	0.99	1.14	1.06	0.89	0.99	0.94
D_3	0.95	0.99	0.97	1.45	1.48	1.46	1.12	1.15	1.13	0.79	0.87	0.83	1.13	1.17	1.15	0.96	1.03	0.99
D_4	0.93	0.97	0.95	1.39	1.47	1.43	1.10	1.14	1.12	0.71	0.85	0.78	1.11	1.15	1.13	0.93	1.00	0.96
Mean	0.89	0.95		1.36	1.43		1.07	1.11		0.70	0.80		1.04	1.11		0.90	0.97	
	D	P	D × P	D	P	D×P	D	P	D×P	D	P	D×P	D	P	D×P	D	P	D×P
SEd	0.009	0.006	0.013	0.018	0.013	0.026	0.012	0.008	0.017	0.010	0.007	0.015	0.013	0.009	0.019	0.015	0.010	0.021
CD (P=0.05)	0.020	0.014	0.029	0.040	0.028	0.057	0.027	0.019	0.038	0.023	0.016	0.032	0.029	0.020	0.041	0.033	0.023	0.047
p-value	0.016			0.309			0.753			0.320			0.157			0.430		

*D_1 – One plant pit^{-1}, D_2 – Two plants pit^{-1}, D_3 – Three plants pit^{-1} and D_4 - Four plants pit^{-1}, *P_1 – One pruning year^{-1} and P_2 – Two prunings year^{-1}

Table 4. Influence of planting density and pruning schedule on physiological and biochemical characters in comparison with conventional planting in *J. sambac* (Pooled means)

Treatment	Total phenol content (mg g^{-1})		Mean	Soluble protein (mg g^{-1})		Mean	IAA oxidase activity (µg of unoxidised auxin g^{-1} h^{-1})		Mean
	P_1	P_2		P_1	P_2		P_1	P_2	
D_1	1.71	1.76	1.73	10.13	10.52	10.32	12.91	13.03	12.97
D_2	1.78	1.95	1.86	10.69	11.71	11.20	13.62	14.41	14.01
D_3	1.88	2.74	2.31	11.56	12.57	12.06	14.39	15.44	14.91
D_4	1.82	2.10	1.96	11.24	11.83	11.53	14.10	14.62	14.36
Mean	1.79	2.13		10.90	11.65		13.75	14.37	
	D	P	D × P	D	P	D × P	D	P	D × P
SEd	0.036	0.025	0.051	0.157	0.111	0.222	0.175	0.124	0.248
CD (P=0.05)	0.077	0.055	0.110	0.337	0.238	0.476	0.376	0.266	0.533
p-value	0.175			0.304			0.249		

*D_1 – One plant pit^{-1}, D_2 – Two plants pit^{-1}, D_3 – Three plants pit^{-1} and D_4 - Four plants pit^{-1}. *P_1 – One pruning $year^{-1}$ and P_2 – Two prunings $year^{-1}$

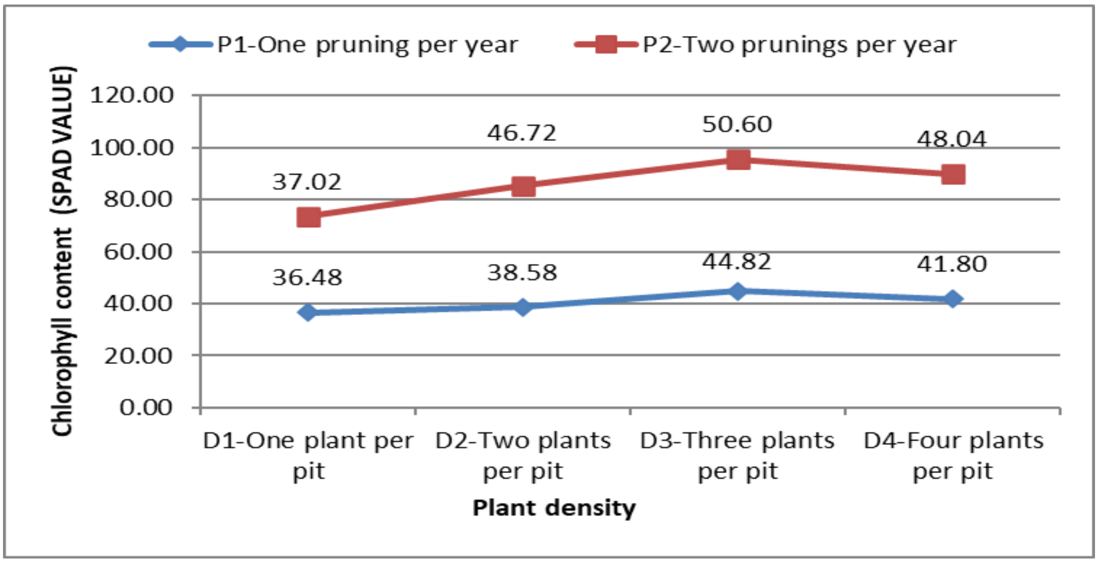

Fig. 4. *Influence of planting density and pruning schedule on chlorophyll content (SPAD value) in J. sambac (Pooled means)*

plants gave the highest quantum of yield, chlorophyll a and b, and maximum flower initiation per plant compared to those of non-pruned plants (Saifuddin *et al.*, 2010). Chaudhuri and Baruah (2010) in Banana (*Musa sp.*) cv. 'Jahaji' (AAA) also observed that higher acidity and non-reducing sugars were found in planting system with higher plant population. Higher acidity may be due to shade effect, where sugar conversion from organic acid is hampered due to lack of sufficient light. Higher non reducing sugars may be due to less sugar conversion from starch. These results also agree with Singh *et al.* (2020), who reported that among the different planting systems and plant density, the square system of planting obtained highest TSS, maximum reducing and non-reducing sugars (12.0 ^{0}B, 5.10% and 7.30%), and the maximum acidity (0.39) obtained in hedge row system in guava (*Psidium guajava* L.) The study on the combined effect of different planting density cum pruning intervals not only provides higher yield but also improves or sustains the flower quality in *J. sambac.* Increasing the flower yield without affecting flower bud quality is more advantageous. Thus the findings of the present study with respect to flower quality and physiological and biochemical parameters are in line with the above reports.

Conclusion

In *Jasminum sambac*, the adoption of optimum plant density, planting system and effective pruning interval is very important to ensure the rapid growth of plants and pave the way for higher economic returns per unit area. The present study led to the inference that increasing the planting density of three plants pit^{-1} and pruning twice a year (D_3P_2) performed better by enhancing the number of flowering shoots. Thus, favourable for the growth and ultimately benefits the flower traits in *J. sambac,* resulting in improved quality flowers by increasing physiological activity in all three seasons (off, peak and lean seasons). This strategy also has immense scope for inducing continuous flowering in *J. sambac*.

Conflict of interest

The authors declare that they have no conflict of interest.

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