International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2023; 11(2): 44-49

Received: 20-01-2023
Accepted: 24-02-2023

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Induction of off season flower production through pruning and foliar application of organic stimulants in Jasmine (*Jasminum sambac* L.)

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Abstract
An investigation was carried out during 2016-2018 at farmer's field in Ayothiapattinum, Salem district of Tamil Nadu to study the effect of time of pruning and foliar application of organic stimulants on growth, flowering and flower yield of jasmine. The experiment was laid out in split plot design and the treatments were replicated thrice. The main plot treatments (four) are *viz.* P_1 – Pruning during the last week of August, P_2 – Pruning during the last week of September, P_3 – Pruning during the last week of October and P_4 – Pruning during the last week of November. The sub plot treatments (six) are *viz.* T_1- Panchakavya 3%, T_2 - Panchakavya 3% + humic acid 0.4%, T_3 - Panchakavya 3% + humic acid 0.4% + tender coconut water 5%, T_4 - Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%, T_5 - Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%. The organic stimulants were applied as foliar spray at 15 days interval from the time of pruning to the flower bud initiation. Data on plant height, number of primary branches, number of secondary branches, total dry matter production, commencement of flowering, number of flowers per plant, weight of single flower bud, weight of flowers per plant and flower yield were observed. The results revealed that the early induction of flowering (46.23 days) and highest flower yield (674.24 $kgha^{-1}$) were obtained in jasmine bushes pruned during the last week of September along with foliar application of Panchagavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5% during the off season period from November to February.

Keywords: Pruning, flowering, organic stimulants, *Jasminum sambac* and flower yield

Introduction
Jasmine is one of the important fragrant flowers used even from very ancient days in India. It is highly esteemed for its attractive, white coloured and a fragrant flower and has a pride of place in the heart of every south Indian woman (Khanchana and Jawaharlal, 2019) [8]. Jasmine (*Jasminum sambac* L.) stands first among the fragrant loose flowers. Jasmine is a very important group of plants which is extensively cultivated in India. India is one of the centers of origin of jasmine. The white and fragrant flowers of jasmine are symbol of purity, eternal love, nobility and also symbolizes the beauty of a girl. It is offered to God and used for worshiping and hence, these are preferably planted in Hindu temple garden and Moghul gardens. Jasmine (*Jasminum sambac* L.) belongs to family Oleaceae and is of about 200 species which are mainly shrubs and climbers (Taj and Naik, 2013) [22]. *Jasminum sambac* (L) is commonly known as Arabian jasmine, Tuscan jasmine, Motia or Mogra having chromosome no. of 2n = 39 and belongs to India. The term Jasmine was derived from Arabic word 'Jessamine' (Bailey, 1947) [2]. It is the national flower of Philippines, where it is known as Sampaquita. India exports fresh jasmine flowers to the neighboring countries including Sri Lanka, Singapore, Malaysia and the Gulf countries and in recent times even to the United States. Jasmine flower crop is grown on commercial scale throughout India, but extensively in Tamil Nadu which is the leading producer of jasmine in the country with an annual production of 1,36,901 tonnes from an area of 13,246 ha with a productivity of 11.21 t/ha (Hort Tech, 2018) [6]. *Jasminum sambac* is commonly known as the "Arabian Jasmine" or "Tuscan Jasmine". It is well distributed in Andhra Pradesh, Karnataka, Tamil Nadu states of India and to some extent in West Bengal (Randhawa and Mukhopadhyay, 1986) [17]. In *Jasminum sambac*, the crop produces good yield during the months starting from march to August. The market price during December to March is 10 times higher than the remaining part of the year. The exorbitant peak price is mainly due to non availability of flowers.

After pruning, the jasmine plants starts bearing and produce large quantity of flowers during June-July which results in reduced market price during this period which sometimes is not even equal to its picking cost (Krishnamurthy, 2014) [10]. Hence, in order to produce Jasmine flowers during off season i.e. December to March, the present study was undertaken to produce jasmine flowers by pruning with application of organic stimulants.

Materials and Methods

The present study was carried out at farmer's field at Ayothiapattinum, Salem district of Tamil Nadu during the period between July 2016 to April 2018. The experiment was conducted in Jasminum sambac (L) cv. Ramanathapuram local Gundumalli in split plot design with four treatments in main plot and six treatments in sub plots. The treatments are replicated thrice. The treatment details are (main plots) *viz*., P_1 – Pruning during the last week of August, P_2 – Pruning during the last week of September, P_3 – Pruning during the last week of October and P_4 – Pruning during the last week of November. The sub plot treatments are *viz*. T_1- Panchakavya 3%, T_2 - Panchakavya 3% + humic acid 0.4%, T_3 - Panchakavya 3% + humic acid 0.4% + tender coconut water 5%, T_4 - Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%, T_5 - Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%. The spacing was 1.25 x 1.25 m. Fully grown up two year old plants were selected for the study. The pruning operations were carried out at the level of 45 cm from the ground level. The different organic stimulants were applied as per the sub plot treatments at 15 days interval starts from the time of pruning to the flower bud initiation. The observations on vegetative growth parameters *viz*. plant height, number of primary branches, number of secondary branches and total dry matter production were made at 15 days after the last spray. Similar to the above, the flowering and yield attributes *viz*., commencement of flowering (after pruning), number of flowers per plant, weight of single flower bud, weight of flowers per plant and flower yield (kg ha^{-1}) were observed and the data were subjected to statistical scrutiny as per the procedure given by Pane and Sukhatme (1985) [15].

Results and Discussion

Plant height differed significantly due to time of pruning and organic stimulants (Table 1). Among the treatment combinations, pruning at last week of August with application of 3% Panchakavya + 0.4% humic acid + 5% tender coconut water + 5% moringa leaf extract (P_1 x T_5) recorded the higher plant height of 70.50 cm than the other interactions.

The number of primary branches was significantly influenced by both time of pruning and organic stimulants (Table 2). Pruning during the last week of September with application of 3% Panchakavya + 0.4% humic acid + 5% tender coconut water + 5% moringa leaf extract (P_2 x T_5) significantly recorded the highest number of primary branches (9.46) as against August month pruning with nil application of organic stimulants (P_1 x T_6) control which recorded the lowest number of primary branches (5.10).

Time of pruning along with combined application of different organic stimulants significantly induced the production of more number of secondary branches (Table 3). The highest number of secondary branches (16.85 per cent) was perceived in September month pruning with application of 3% Panchakavya + 0.4% humic acid + 5% tender coconut water + 5% moringa leaf extract (P_2 x T_5). However, the lowest number of secondary branches (8.21 per plant) was obtained in November month pruning with control (P_4 x T_6).

The total dry matter production, as one of the important index of plant growth, was significantly influence by different time of pruning as well as due to the application of various source of organic stimulants (Table 4). Among the different interactions, pruning carried out during the last week of September in collaboration of foliar application of 3% Panchakavya + 0.4% humic acid + 5% tender coconut water + 5% moringa leaf extract (P_2 x T_5) recorded the highest dry matter production (698.77 g $plant^{-1}$) as against the August month pruning with (P_2 x T_6) nil applications (control) which recorded the lowest total dry matter production (445.01).

Pruning is an important tool for manipulation of flowering as it influences the flower bud initiation, differentiation and ultimately flower production. Plants are pruned by removing all past season shoots including dead and diseased branches to a height of about 45 cm from the ground level. All the leaves in the bushes are stripped off. It is carried out in a way that the lower branches take the sufficient light for photosynthesis, to improve the shape of the plant and to make the plant healthier (Calatayud *et al.,* 2007) [4]. The results of the present investigation revealed that pruning during the last week of September along with organic stimulants performed better and produced more number of primary and secondary branches and hence total dry matter production. This might be attributed to the fact that September pruning resulted in more foliage. This might be due to the enhanced light interceptions and air penetration into the canopy due to pruning leads to higher photosynthesis and ultimately large reserve food sources leading to production of more total dry matter production (Suganya *et al.,*2023) [20]. Similar finding was also reported by Nandhini *et al.* (2018) [14]. Who reported that September pruning is ideal for off season production in Gundumalli. The present study was in concurrence with the findings of Nair *et al.* 2009 [23].

Flower characteristics and flower yield

The commencement of days to flowering after pruning varied significantly due to treatments (Table 5). The earliest flowering (46.23 days) was observed in September month pruning with the application of organic stimulants *viz*., Panchakavya 3% + humic acid 0.4% + tender coconut 5% + moringa leaf extract 5% (P_2 x T_5). In contrast, August month flowering with nil application of organic stimulants (P_1 x T_6) took more number of days for commencement of flowering (62.69 days). The induction of off season flowering in September month flowering might be due to the hormonal balance in the shoots as well as hormonal effect of different organic biostimulants. This findings is in consonance with the result of Naik *et al.,* (2019) [12].

Data on the number of flowers per plant are presented in Table 6. The number of flower per plant was significantly influenced by both main plot, sub plot treatments and their interactions. Pruning during the last week of September with application of Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5% (P_2 x T_5) recorded higher number of flowers per plant than the other treatment combinations. This might be due to production of more number of branches which ultimately leads to production of more flowers (Kumaresan, 2016) [11]. Production of more number of flowers in September month pruning in the present study is in agreement with the findings of Khanchana and Jawaharlal (2019) [8]. The synergistic effects of moringa leaf extract and tender coconut which

contain (zeatin) cytokinin are also responsible for more number of flowers in September month pruning with organic stimulants application Singh *et al.,* (2020) [3]. Humic acid through enzymatic action (Bayat *et al.,* 2021) [3] and therefore more number of flowers per plant was achieved.

The size of the flowers as measured by weight of single flower bud was significantly influenced by time of pruning and application of biostimulants (Table 7). The maximum flower bud (0.216 g bud^{-1}) was obtained in jasmine bushes which received panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5% in September month pruning (P_2 x T_5). The August month pruning with nil application (control) of organic stimulants (P_1 x T_6) recorded the lowest single flower bud weight (0.146 g bud^{-1}). Pruning during the September month helps in rejuvenation and encouraging growth of new healthy shoots and further accumulated more photosynthates. Besides pruning, exogenous application of organic stimulants accelerates the mobilization of source to sink are the probable season for the higher flower bud weight in September pruning combined with

spray of different organic stimulants. Similar results were also reported by Akanksha *et al.,* (2021) [1].

Data regarding the weight of flower buds per plant are presented in Table 8. It was revealed from the data that the weight of flower buds per plant was significantly influenced by time of purning and application of organic stimulants. The maximum weight of flower bud (105.35 g plant^{-1}) was recorded in (P_2) September month pruning bushes / plant which received (T_5) panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%. The lowest of flower buds per plant (29.86 g plant^{-1}) was observed in jasmine plant which has not received any organic stimulants in November month pruning (P_4 x T_6). The enhanced weight of flower buds per plant in September month pruning (P_2) with application of different organic stimulants (T_5) in the present study might be due to the synergistic effect of both pruning and organic stimulants. Nandhini *et al.,* (2018) [14] reported that positive influence of pruning as well as organic stimulants season to be mediated through increased number branches and photosynthesis which leads to more number of flowers. Similar results was also reported by Harkulkar *et al.,* (2022) [5].

The time of pruning and application of various organic stimulants significantly influenced the yield potential of jasmine flowers (Table 9). Jasmine plants pruned during the last week of September month (P_2) and application of Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5% (T_5) enhanced the yield potential of jasmine bushes and recorded the flower yield of 674.24 kg ha^{-1} during the off season period. In contrast to the above, the jasmine plant pruned during the November month and nil application (control) recorded the lowest flower yield (186.94 kg ha^{-1}).

In the present study, it was evident that jasmine bushes pruned during the last week of September (P_2) and foliar applied organic biostimulants solutions *viz.,* Panchakavya 3% + humic acid 0.4% + coconut water 5% + moringa leaf extract 5% (T_5) after pruning with 15 days interval to flower bud initiation enhanced the flower yield during the off season. Pruning during the month of September increased the number of branches which might have ultimately resulted in increased yield of flowers. Flower yield is depend upon the number of branches. Nair *et al.* 2009 [23] also obtained highest flower yield in jasmine in September pruned plants. The optimum temperature prevailed thereafter pruning in the month of October and November coincided with short day conditions prevailed during the following winter period might have induced the profuse flowering (Suresh Kumar *et al.,* 2021) [21].

In addition to the pruning, organic stimulants also played a major role in enhancing the flower yield. Panchagavya includes serial vitamins, micronutrients, amino acids and plant hormones (Ram, 2017) [16]. The presence of carboxyl and phenolic groups in humic acid responsible for the early flower induction and yield (Schnitzer 1992) [18]. Tender coconut water contains plant hormones *viz.,* cytokinins, auxins, gibberellins, amino acids amines and nucleic acid (Krishnamoorthy, 1993) [9]. Moringa leaf extracts contains abundant minerals, phytohormones and antioxidants (Singh *et al.* 2020; Jhilik *et al.,* 2017) [19, 7].

Table 1: Effect of time of pruning and organic stimulants on plant height (cm) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	61.23	60.40	61.25	59.56	60.61
T_2	Panchakavya 3% + humic acid 0.4%	63.45	61.25	62.43	60.25	61.84
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	65.64	62.75	62.58	62.24	63.30
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	67.32	64.33	63.25	63.21	64.52
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	70.50	67.54	65.24	64.28	66.89
T_6	Control	58.15	56.12	57.37	56.25	56.97
	Mean	64.38	62.06	62.02	60.96	
		P	T		P X T	
	SE (d)	0.023	0.028		0.057	
	CD (P=0.05)	0.057	0.058		0.165	

Table 2: Effect of time of pruning and organic stimulants on primary branches (Nos plant^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	6.52	7.63	6.76	6.65	6.89
T_2	Panchakavya 3% + humic acid 0.4%	6.38	8.52	7.21	7.66	7.44
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	6.80	8.32	7.50	7.93	7.63
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	6.90	8.54	8.20	8.10	7.93
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	7.20	9.46	8.53	9.35	8.63
T_6	Control	5.10	6.40	6.10	6.00	5.88
	Mean	6.47	8.14	7.38	7.61	

		P	T	P X T
	SE (d)	0.011	0.018	0.007
	CD (P=0.05)	0.027	0.040	0.016

Table 3: Effect of time of pruning and organic stimulants on secondary branches (Nos plant^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	9.32	11.48	10.25	10.23	10.32
T_2	Panchakavya 3% + humic acid 0.4%	10.25	12.35	11.23	11.25	11.27
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	12.98	14.69	12.98	12.63	13.32
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	13.12	14.25	12.57	12.34	13.07
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	16.32	16.85	14.54	15.50	15.80
T_6	Control	8.36	9.45	8.86	8.21	8.72
	Mean	11.72	13.17	11.74	11.69	
		P	T		P X T	
	SE (d)	0.011	0.020		0.039	
	CD (P=0.05)	0.029	0.041		0.081	

Table 4: Effect of time of pruning and organic stimulants on total dry matter production (g plant^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	491.60	501.45	478.41	521.92	498.34
T_2	Panchakavya 3% + humic acid 0.4%	512.08	520.45	492.81	515.74	510.44
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	542.52	550.66	538.94	550.95	545.76
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	609.21	627.99	613.68	618.32	617.28
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	650.52	698.77	493.38	693.17	633.96
T_6	Control	445.01	470.28	454.38	464.62	458.57
	Mean	541.94	561.58	511.93	560.78	
		P	T		P X T	
	SE (d)	0.379	0.621		1.197	
	CD (P=0.05)	0.929	1.256		2.471	

Table 5: Effect of pruning and organic stimulants on commencement of flowering (days) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	60.10	48.74	58.42	61.42	57.17
T_2	Panchakavya 3% + humic acid 0.4%	58.50	48.36	57.20	59.52	55.89
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	59.45	47.52	56.75	59.42	55.78
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	58.56	47.20	55.15	55.52	54.10
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	57.87	46.23	54.58	54.25	53.23
T_6	Control	62.69	50.30	60.53	63.32	59.21
	Mean	59.52	48.05	57.10	58.90	
		P	T		P X T	
	SE (d)	0.087	0.019		0.093	
	CD (P=0.05)	0.212	0.038		0.223	

Table 6: Effect of pruning and organic stimulants on number of flowers per plant (Nos plant^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	279.31	367.79	324.28	234.82	301.54
T_2	Panchakavya 3% + humic acid 0.4%	287.65	390.50	368.71	259.24	326.48
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	299.26	411.48	395.00	267.47	343.38
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	304.49	439.63	421.69	283.16	362.24
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	334.07	488.19	442.26	338.63	400.78
T_6	Control	242.34	254.82	240.72	193.94	233.01
	Mean	291.18	392.07	365.51	262.87	
		P	T		P X T	
	SE (d)	0.993	0.499		1.348	
	CD (P=0.05)	2.431	1.009		3.037	

Table 7: Effect of pruning and organic stimulants on weight of single flower bud (g bud^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	0.163	0.182	0.161	0.160	0.167
T_2	Panchakavya 3% + humic acid 0.4%	0.172	0.187	0.165	0.162	0.172
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	0.179	0.189	0.168	0.165	0.175
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	0.187	0.193	0.171	0.169	0.180
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	0.202	0.216	0.178	0.174	0.193
T_6	Control	0.146	0.163	0.152	0.154	0.154
	Mean	0.175	0.188	0.166	0.164	
		P	T		P X T	
	SE (d)	0.0001	0.0001		0.0002	
	CD (P=0.05)	0.0004	0.0002		0.0006	

Table 8: Effect of pruning and organic stimulants on weight of the flower buds per plant (g plant^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	45.52	66.93	52.21	37.56	50.56
T_2	Panchakavya 3% + humic acid 0.4%	49.47	73.02	60.81	41.99	56.32
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	53.56	77.77	66.41	44.13	60.47
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	56.94	84.94	72.10	47.85	65.43
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	67.48	105.35	78.72	58.92	77.64
T_6	Control	35.38	41.53	36.63	29.86	35.85
	Mean	51.39	74.92	56.60	43.38	
		P	T		P X T	
	SE (d)	0.221	0.121		0.313	
	CD (P=0.05)	0.542	0.245		0.700	

Table 9: Effect of pruning and organic stimulants on flower yield per hectare (kg ha^{-1}) in jasmine

Organic stimulants		Time of pruning				Mean
		P_1- Last week of August	P_2- Last week of September	P_3 – Last week of October	P_4 – Last week of November	
T_1	Panchakavya 3%	290.49	429.31	334.53	240.45	323.59
T_2	Panchakavya 3% + humic acid 0.4%	317.18	466.11	390.27	269.95	360.49
T_3	Panchakavya 3% + humic acid 0.4% + tender coconut water 5%	344.38	499.26	427.01	282.43	387.02
T_4	Panchakavya 3% + humic acid 0.4% + moringa leaf extract 5%	363.32	543.62	461.50	305.54	418.80
T_5	Panchakavya 3% + humic acid 0.4% + tender coconut water 5% + moringa leaf extract 5%	431.87	674.24	504.64	377.09	496.92
T_6	Control	225.79	266.43	234.30	186.94	229.46
	Mean	328.93	479.54	391.36	277.69	
		P	T		P X T	
	SE (d)	1.419	0.777		2.007	
	CD (P=0.05)	3.472	1.571		4.484	

Conclusion

From the above results, it was concluded that pruning during last week of September along with foliar application panchagavya 3% + humic acid 0.4% + coconut water 5% + moringa leaf extract of 5% after pruning with 15 days interval upto flower bud initiation can be recommended to induce off season flowering (November to February) in Jasmine flowers (*Jasminum sambac* L.)

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