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Standardization of pruning month and growth regulators application on flower quality characteristics of jasmine (*Jasminum sambac* (L.) aiton) during off season flower production under polyhouse condition

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Abstract
The experiment was carried out during 2021-2023 at the Department of Horticulture, UAS, GKVK, Bengaluru to study the influence of pruning and application of growth regulators on flower quality characteristics of jasmine (*Jasminum sambac* (L.) Aiton) during off-season flower production under polyhouse condition. There were three pruning treatments were imposed during the second fortnight of August (P_1), October (P_2) and December (P_3 control). Foliar application of growth regulators *viz*., GA_3 at 100 (G_1), 150 (G_2), and 200 ppm (G_3); Cycocel at 500 (G_4), 750 (G_5), and 1000 ppm (G_6) and double distilled water (Control, G7) were sprayed at 15 days after pruning under polyhouse condition. Combination of pruning and growth regulators comprising of 21 treatments with three replications laid out in Factorial Completely Randomized Design (FCRD). Among the off-season pruning treatment, the interaction between P_2G_6, which involves pruning in October coupled with foliar spray of Cycocel at 1000 ppm, resulted in the highest chlorophyll content during peak vegetative period *i.e*., 57.00 in November and during flowering chlorophyll content of 58.25 was recorded in January. Flower quality characteristics *viz*., corolla tube length (1.600 cm), bud length (1.850 cm) and flower diameter (3.830 cm) were significantly maximum in plant pruned with October pruning with GA_3 at 200 ppm. While, bud diameter (1.317 cm) and 100 buds weight (51.270 g) higher in P_2G_6 (October pruning + Cycocel at 1000 ppm). Shelf life showed no significant difference among the treatments. Off season flower yield per ha (1.628 kg) was maximum in plants pruned during October month with application of Cycocel at 1000 ppm (P_2G_6).

Keywords: Jasmine, off season, pruning, growth regulators

Introduction

Jasmine (*Jasminum* spp.) holds a significant historical and cultural significance in India. This fragrant flower has been cherished since ancient times and is particularly adored by South Indian women. Its allure lies in its beautiful white blossoms with a captivating fragrance with great economic importance for the florist, landscapers, medicinal, pharmaceutical and fragrance industries. As a florist, Jasmine plants are grown for ornamental purposes and as loose flowers to make veni and garlands. India exports fresh Jasmine flowers to the neighbouring countries like Sri Lanka, Singapore, Malaysia and the Gulf countries. This flower crop is grown on commercial scale throughout India, but extensively in Tamil Nadu, Karnataka and Andhra Pradesh. In Karnataka, it is mainly grown in Bengaluru, Bellary, Chitradurga, Mysore, Dharwad, Udupi and Gadag districts with an area of 3.23 thousand hectares and production of 23.88 thousand MT with 7.39 MT productivity.

Jasmine can be grown in a variety of climate and soils as an open field crop. It is generally recommended to have a mild tropical climate for proper growth and flowering. *Jasminum sambac* requires dry and warm climatic conditions with an optimum temperature of 27-32 °C during day time and 21-27 °C at night with low humidity is ideal for flowering and peak flowering season is from March to July. Growth and flowering are facilitated by the sandy loam soil with a comparatively high pH that prevails in the regions of Bengaluru and surrounding areas (Navya 2023) [4].

Ultra-structural cellular changes in the flowers caused by low winter temperatures result in a decrease in their growth and yield (Su *et al*., 2001) [6]. Therefore, the flowering of *Jasminum sambac* is limited to summer months. However, there is lot of demands for the flowers in other seasons in which most of the festivals fall in. The flower production is reduced during cooler months, leading to hike in price during September to February is almost ten times higher than the remaining part of the year that can be termed as "off- season" in Jasmine cultivation (Krishnamoorthy, 2014) [2]. Due to this peculiar flowering habit there is no continuous and uniform supply of flowers to the market during this period. Due to this, there is scarcity during the lean season and glut during the peak season, resulting in significant fluctuations in price, demand, and supply. Inducing flower production and regulating flowering in Jasmine is of immense practical value when done by any method.

Foliar spray of GA_3 enhances early phase of vegetative growth which favoures the cell enlargement and cell division activities in the plant, increasing photosynthesis and CO_2 fixation. Further, it has also favoured floral quantity influencing carbohydrate pathway and photo periodic pathway with GA, pathway (Sobhana *et al.*, 2014) [5]. Spray of Cycocel produces compact growth, increases the number of shoots, early bud initiation due to it improved the nutrients uptake from the soil and increasing the nutrient use efficiency for better synthesis of assimilates in the large photosynthetic area and optimum nourishment to the growing meristematic tissues.

Protected cultivation is an innovative way of raising seasonal and off-seasonal crops under a partially controlled environment. Flower crops have tremendous potential to augment productivity, generate employment, utilize land efficiently and enhance export. Growers in India with marginal and small land holdings can benefit from protected cultivation, which enables them to produce more crops from their land each year, especially during the off-season when prices are higher. Jasmine's suitability for cultivation under protection has less scientific investigated so far.

Materials and Methods

The research was conducted at the Department of Horticulture, UAS, GKVK, Bengaluru, from 2021 to 2023. The experimental site was situated in Zone-5 of Karnataka's Eastern dry zone, at approximately 13°05" North latitude and 77°34" East longitude, with an elevation around 924 meters above sea level. The study employed a Factorial Completely Randomized Design (FCRD) with three replications, comprising 21 treatments. These treatments were designed to investigate the combined impact of pruning and various concentrations of growth regulators on inducing off-season flowering under polyhouse condition. Pruning was carried out at 45cm above ground level during the second fortnight of August (P1), October (P2), and in December (regular pruning), followed by application of different concentrations of plant growth regulators fifteen days later. The growth regulators used included GA3 at 100 ppm (G1), GA3 at 150 ppm (G2), GA3 at 200 ppm (G3), Cycocel at 500 ppm (G4), Cycocel at 750 ppm (G5), Cycocel at 1000 ppm (G6), and double distilled water as the control (G7). The data observed on Flower quality parameters like chlorophyll pigment, corolla tube length, bud length, bud diameter, flower diameter, 100 bud weight, shelf life, on season and off-season yield were also recorded. The data were subsequently analyzed using OPSTAT.

Result and Discussion

Effect of Pruning and Growth Regulators on Flower characteristics of *J. sambac*

The chlorophyll content of leaves during the stages of grand vegetative growth and peak flowering showed significant variations across various treatments, as influenced by the time of pruning, growth regulators, and their interaction presented in Table 1. Interaction effect between the month of pruning and application of growth regulators showed significant variation among the treatments. In particular, the treatment combination having P_3G_6, (pruning in December along with the application of Cycocel at 1000 ppm), resulted in highest chlorophyll content in the leaf. Peak chlorophyll content was observed in the month of January during vegetative phase (57.67) and during flowering in April (53.82). Among the off-season pruning treatment, the interaction between P_2G_6, which involves pruning in October coupled with foliar spray of Cycocel at 1000 ppm, resulted in the highest chlorophyll content during peak vegetative period *i.e*., 57.00 in November and during flowering chlorophyll content of 58.25 was recorded in January. Minimum chlorophyll content of the leaf (43.83 during September and 45.08 during November) was recorded in plants pruned during August with GA_3 at 200 ppm (P_1G_3). Attributed to the fact that early-pruned plants are being benefited by the favourable climatic conditions. Pruning plays an important role in breaking dormancy and promoting the growth of new sprouts. Additionally, application of cycocel to plants represses the growth of stems and leaves but improves photosynthetic capacity by increasing leaf chlorophyll content (Jyothi and Tambe, 2019) [3] in okra.

One of the most crucial factors in attracting customers in local and markets and export is flower quality. Different pruning months and growth regulators had a big impact on the flower quality parameters *viz*., flower bud diameter, flower bud length, corolla tube length, flower diameter, and 100 bud weight and data presented in Table 2, 3 and 4. The interaction effect of P x G revealed that, plants pruned during October along with foliar spray of GA_3 at 200 ppm (P_2G_3) recorded significantly highest off-season flower corolla tube length (1.223 cm), bud length (1.400 cm) and flower diameter (3.830 cm) followed by P_2G_2 *i.e.*, plant pruned during October with GA_3 at 150 ppm and P_2G_3 (October with Cycocel at 500 ppm). Least off-season flower corolla tube length (0.907 cm), bud length (0.950 cm) and total flower length (1.857 cm) respectively, was recorded in P_1G_7 (August pruned without growth regulators) treatment combination. This resulted due to October pruned plants starts produces the flowers during November month, plants being exposed to lowest temperature was 17.89 °C with 11-12 °C higher diurnal variation. These factors certainly had an impact on the quality parameters. A boost in photosynthesis and CO_2 fixation was probably caused by the external application of GA_3 (Navya, 2023) [4]. Additionally, it may have facilitated the coordination of various factors affecting floral quality, including the carbohydrate and the photoperiodic pathway, through the influence of the GA_3 pathway.

The data on shelf life as influenced by month of pruning, plant growth regulators and their interaction effects both on and off-season flowering are presented in Table 4. The data did not exhibit statistically significant differences among the treatment.

Table 1: Effect of pruning, plant growth regulators and their interaction on Chlorophyll pigment in *Jasminum sambac* under polyhouse condition

Treatments	Chlorophyll pigment (vegetative phase)				Chlorophyll pigment (Flowering phase)			
	August	October	December	Mean	August	October	December	Mean
GA_3 at 100 ppm	46.67^{ij}	53.67^{de}	55.33^{bcd}	47.03^{bc}	47.92^{ij}	54.92^{de}	56.58^{bcd}	53.14^{bc}
GA_3 at 150 ppm	44.40^{k}	53.00^{def}	53.00^{def}	45.13^{cd}	45.65^{k}	54.25^{def}	54.58^{def}	51.49^{c}
GA_3 at 200 ppm	43.83^{k}	49.33^{gh}	48.33^{hi}	42.17^{d}	45.08^{k}	50.58^{gh}	49.58^{hi}	48.42^{d}
Cycocel at 500 ppm	47.47^{hij}	52.33^{ef}	53.00^{def}	45.93^{bc}	48.72^{hij}	53.58^{ef}	54.25^{def}	52.18^{c}
Cycocel at 750 ppm	51.27^{fg}	54.00^{cde}	56.00^{abc}	48.76^{ab}	52.52^{fg}	55.25^{cde}	57.25^{abc}	55.01^{b}
Cycocel at 1000 ppm	54.73^{cd}	57.00^{ab}	57.67^{a}	51.47^{a}	55.98^{cd}	58.25^{ab}	58.92^{a}	57.72^{a}
Double distilled water (Control)	46.00^{jk}	47.67^{hij}	49.00^{h}	42.56^{d}	47.25^{jk}	48.92^{hij}	50.25^{h}	48.81^{d}
Mean	47.77^{b}	52.43^{a}	53.19^{a}		49.02^{b}	53.68^{a}	54.49^{a}	
(P×G) SE(d)	1.019				1.169			
(P×G) CD	2.064				2.367			

Table 2: Influence of pruning month, plant growth regulators and their interaction on number of primary branches, number of secondary branches and Leaf area in *Jasminum sambac* under polyhouse condition

Treatments	Corolla tube length (cm)				Bud length (cm)			
	August	October	December	Mean	August	October	December	Mean
GA_3 at 100 ppm	1.300^{def}	1.367^{cde}	1.300^{def}	1.322^{bc}	1.500^{defg}	1.600^{bcd}	1.550^{bcdef}	1.550^{b}
GA_3 at 150 ppm	1.333^{cdef}	1.400^{bc}	1.383^{cd}	1.372^{b}	1.517^{cdefg}	1.617^{bc}	1.567^{bcdef}	1.567^{b}
GA_3 at 200 ppm	1.383^{cd}	1.600^{a}	1.467^{b}	1.483^{a}	1.633^{b}	1.850^{a}	1.600^{bcd}	1.694^{a}
Cycocel at 500 ppm	1.283^{ef}	1.400^{bc}	1.350^{cdef}	1.344^{b}	1.483^{efg}	1.583^{bcde}	1.550^{bcdef}	1.539^{b}
Cycocel at 750 ppm	1.267^{fg}	1.350^{cdef}	1.300^{def}	1.306^{bc}	1.500^{defg}	1.567^{bcdef}	1.517^{cdefg}	1.528^{bc}
Cycocel at 1000 ppm	1.200^{gh}	1.300^{def}	1.283^{ef}	1.261^{c}	1.467^{fg}	1.55^{bcdef}	1.483^{efg}	1.500^{bc}
Double distilled water (Control)	1.150^{h}	1.283^{ef}	1.333^{cdef}	1.256^{c}	1.333^{h}	1.533^{bcdef}	1.417^{gh}	1.428^{c}
Mean	1.274^{b}	1.386^{a}	1.345^{ab}		1.490^{b}	1.614^{a}	1.526^{ab}	
(P×G) SE(d)	0.034				0.041			
(P×G) CD	0.068				0.083			

Table 3: Effect of pruning month, plant growth regulators and their interaction on flowering behaviour in *Jasminum sambac* under polyhouse condition

Treatments	Bud diameter (cm)				Flower diameter (cm)			
	August	October	December	Mean	August	October	December	Mean
GA_3 at 100 ppm	1.017^{de}	1.083^{cd}	1.083^{cd}	1.061^{ab}	3.230^{def}	3.370^{cd}	3.230^{def}	3.280^{bc}
GA_3 at 150 ppm	1.000^{de}	1.050^{cde}	1.117^{bcd}	1.056^{ab}	3.330^{d}	3.470^{bc}	3.330^{d}	3.380^{b}
GA_3 at 200 ppm	0.900^{e}	1.150^{bcd}	1.067^{cd}	1.039^{b}	3.530^{b}	3.830^{a}	3.570^{b}	3.640^{a}
Cycocel at 500 ppm	1.050^{cde}	1.183^{abc}	1.033^{cde}	1.089^{ab}	3.170^{efg}	3.270^{de}	3.100^{fgh}	3.180^{cd}
Cycocel at 750 ppm	1.067^{cd}	1.250^{ab}	1.083^{cd}	1.133^{ab}	3.000^{hi}	3.170^{efg}	3.070^{ghi}	3.080^{de}
Cycocel at 1000 ppm	1.150^{bcd}	1.317^{a}	1.117^{bcd}	1.194^{a}	2.970^{hi}	3.070^{ghi}	2.950^{i}	2.990^{ef}
Double distilled water (Control)	1.083^{cd}	1.083^{cd}	1.050^{cde}	1.072^{ab}	2.730^{j}	2.970^{hi}	3.030^{ghi}	2.910^{f}
Mean	1.038^{a}	1.160^{a}	1.079^{a}		3.140^{b}	3.310^{a}	3.180^{b}	
(P×G) SE(d)	0.062				0.060			
(P×G) CD	0.125				0.126			

Table 4: Effect of pruning, plant growth regulators and their interaction on off- season duration of flowering and on-season duration of flowering in *Jasminum sambac* under polyhouse condition

Treatments	100 flower bud weight (g)				Shelf life (hr.)			
	August	October	December	Mean	August	October	December	Mean
GA_3 at 100 ppm	35.930^{gh}	41.830^{de}	43.330^{cd}	40.370^{d}	38.33	38.50	38.50	38.44
GA_3 at 150 ppm	34.300^{hi}	42.200^{de}	37.100^{fg}	37.870^{e}	38.17	38.50	38.50	38.39
GA_3 at 200 ppm	34.000^{i}	44.330^{c}	35.700^{gh}	38.010^{e}	38.17	38.50	38.50	38.39
Cycocel at 500 ppm	34.330^{hi}	47.930^{b}	44.400^{c}	42.220^{c}	38.67	39.00	39.00	38.89
Cycocel at 750 ppm	35.930^{gh}	49.670^{a}	50.200^{a}	45.270^{b}	39.17	39.17	39.00	39.11
Cycocel at 1000 ppm	41.100^{e}	50.000^{a}	51.270^{a}	47.460^{a}	39.17	39.00	39.00	39.06
Double distilled water (Control)	33.230^{i}	43.000^{cd}	38.130^{f}	38.120^{e}	38.67	38.50	38.17	38.44
Mean	35.550^{c}	45.570^{a}	42.880^{b}		38.62	38.74	38.67	
(P×G) SE(d)	0.748				0.797			
(P×G) CD	1.514				NS			

Effect of Pruning and Growth Regulators on Flower yield characteristics of *J. sambac*

The data regarding off-season flower yield per hectare is presented in Table 5. Significant differences were noted in the interaction effect. The highest flower yield per hectare (1.628 t) was observed when plants were pruned in October and subsequently sprayed with Cycocel at 1000 ppm, followed by October pruning with Cycocel at 750 ppm (P2G5). Lowest yield per hectare (0.859 t) was recorded in the treatment where pruning was carried out in August without the application of any growth regulators (P1G7). Similar results were recorded by Krishnamoorthy (2014) [2]; Kumaresan (2017) [1]; Sujatha *et al.*

(2009) [7].

The improved transfer of photosynthetic products from their source to where they are required (the ' source to sink') is believed to account for the results obtained in this experiment. The controlled environment of a polyhouse, increased chlorophyll levels, and an increased abundance of leaves all contribute to favourable climate conditions that protect plants against external disturbances. These conditions are beneficial for achieving higher yields during October along with an application of Cycocel, it will redirect the plant's energy away from excessive vegetative growth and towards flowering. The quantity of flowers produced and the duration of flowering can be increased by this approach, as demonstrated by Tannirwar *et al.* (2011) [8] in chrysanthemum.

The on-season flower yield of *Jasminum sambac* during February to July month as influenced by the months of pruning, plant growth regulators, and their interactions on flower yield are shown in Tables 5. The interaction effect between pruning and growth regulators application resulted that highest 100 flower bud wight (51.27 g) and on- season flower yield per plant and per ha (10.332 t) was observed in December pruning with Cycocel at 1000 ppm spraying, followed by December pruning with Cycocel at 750 ppm (P2G5). Among off-season pruning, the highest 100 flower bud wight (50.00 g) yield and per ha (10.059 t) was observed in October pruning with Cycocel at 1000 ppm (P2G6).

The current study demonstrated that plants pruned in December yield more compared to those pruned off-season, possibly due to pruning during cooler months which helps overcome plant dormancy, leading to increased shoot formation, plant height, and spread. Furthermore, on-season flower production begins in February. During pruning, low temperatures and light intensity were recorded. As flowering commences, temperatures and light intensity increase under Bengaluru conditions. Additionally, the application of Cycocel can enhance flower production by shifting the plant's energy from excessive vegetative growth towards flower yield. This results in a more abundant and prolonged flowering period, ultimately increasing yield, as observed in chrysanthemums by Tannirwar *et al.* (2011) [8].

Table 5: Flower yield per plant as influenced by pruning month, plant growth regulators and their interaction in *Jasminum sambac* under polyhouse condition

Treatments	Off season yield per ha (tonnes)				On season yield per ha (tonnes)			
	August	October	December	Mean	August	October	December	Mean
GA_3 at 100 ppm	1.227^{f}	1.465^{cd}	0.000^{j}	0.897^{c}	5.705^{k}	7.707^{f}	8.766^{d}	7.393^{d}
GA_3 at 150 ppm	1.110^{g}	1.347^{e}	0.000^{j}	0.819^{d}	6.068^{j}	6.867^{gh}	7.003^{gh}	6.646^{e}
GA_3 at 200 ppm	0.993^{h}	1.308^{e}	0.000^{j}	0.767^{de}	5.917^{jk}	6.754^{hi}	6.516^{i}	6.396^{e}
Cycocel at 500 ppm	1.344^{e}	1.428^{d}	0.000^{j}	0.924^{c}	6.57^{i}	7.73^{f}	9.241^{c}	7.847^{c}
Cycocel at 750 ppm	1.418^{d}	1.526^{b}	0.000^{j}	0.981^{b}	7.121^{g}	8.692^{d}	9.972^{b}	8.595^{b}
Cycocel at 1000 ppm	1.496^{bc}	1.628^{a}	0.000^{j}	1.041^{a}	8.364^{e}	10.059^{b}	10.332^{a}	9.585^{a}
Double distilled water (Control)	0.859^{i}	1.333^{e}	0.000^{j}	0.731^{e}	4.428^{m}	4.856^{l}	6.064^{j}	5.116^{f}
Mean	1.207^{b}	1.434^{a}	0.000^{c}		6.311^{c}	7.524^{b}	8.270^{a}	
(P×G) SE(d)	0.022				0.134			
(P×G) CD	0.045				0.272			

Conclusion

The research demonstrated that off-season pruning, specifically in October with a foliar application of Cycocel at 1000 ppm applied 15 days after pruning, improved flower quality parameters and increased off-season flower production and yield in *J. sambac* grown under polyhouse conditions. Flowering occurred earlier with enhanced quality and yield in the polyhouse environment.

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