INDUCTION OF OFF-SEASON FLOWERING IN JASMINE (*Jasminum sambac* L.)

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(2019-12-036)

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VELLANIKKARA, THRISSUR - 680 656

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By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Induction of offseason flowering in jasmine (*Jasminum sambac* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara

Date: 26-11-2021

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CERTIFICATE

Certified that the thesis entitled **"Induction of offseason flowering in jasmine (*Jasminum sambac* L.)"** is a record of research work done independently by **Ms. Sandra Santhosh (2019-12-036)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

ºC	Degree celsius
%	Percent
et al.	Co-author/ Co-worker
g	gram
mm	Millimetre
cm	Centimetre
mg/ g	Milligram per gram
ppm	Parts per million
GA_3	Gibberellic acid
CO_2	Carbon dioxide
CD	Critical difference
NS	Non significant
cv.	Cultivar
sp. or spp.	Species (Singular and plural)

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Sandra Santhosh

Dedicated to

My Grandma

(Mrs. Annamma Devassy)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

1. INTRODUCTION

Jasmine is an important commercial loose flower crop that is primarily produced for fresh flowers and essential oil. Flowers are used for making garlands, hair adornments and for worship since ancient times. The blooms are utilised to extract the essential oil, which is used in the production of high-end perfumes. The fragrance of jasmine can not be replaced by synthetic chemicals, hence the essential oil of jasmine fetches a high price in the perfumery industry (Ahmad, 2012).

Jasminum spp. belongs to the family Oleaceae and there are 300 species of jasmine in the genus *Jasminum* (Bhattacharjee, 1983). In India, the important species in cultivation are *J. sambac* (Mulla/ Malli), *J. grandiflorum* (Pitchi) and *J. auriculatum* (Mullai). Jasmines are commercially cultivated in the states of Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal and Odisha. It is anticipated that jasmines cover an area of 8000 hectares, with an annual yield of blooms worth Rs. 80 to 100 million. In India, Tamil Nadu has the largest area under jasmine cultivation followed by Karnataka, which together accounts for 98 per cent of the total cultivated area. Tamil Nadu is the leading producer of jasmine in the country with an annual production of 1,09,250 t from the cultivated area of 10,838 ha (NHB, 2015).

Jasminum sambac is an evergreen shrub that grows to a height of one to three metres under favourable conditions. The leaves are simple, oval and are opposed to or in whorls of three. Flowers appear in clusters of three to twelve which are highly fragrant and white in colour. Plants are cultivated as shrubs as well as climbers and are usually propagated by cuttings and layering (Bhattacharjee, 1994). Kerala has a very good potential for jasmine production especially *Jasminum sambac*. Farmers are following homestead cultivation of *Jasminum sambac* in districts such as Alappuzha, Palakad and Thrissur.

Regulation of flowering in jasmine has immense practical value. Timing of the peak flowering to coincide with the time of greatest demand and generally modifying the flower production to avoid peak production at about the same time would confer great advantages to the grower and consumers. Since flowering is seen in the current season growth, the shrubs are pruned to control growth in bushes and to boost bloom

production. After pruning the jasmine plants start bearing and producing a large number of flowers during the peak season (June-July) which results in reduced market price during this period (Kalaimani, *et al*. 2017).

Due to the disclosed potential of many key processes in plants, the practical application of plant growth regulators in floriculture has taken on a varied dimension, resulting in a scenario that is on the verge of becoming a horticultural revolution. Plant growth regulators are organic compounds other than nutrients that, when employed in tiny amounts, can affect or regulate physiological processes in plants. In the process of floral bud induction, naturally occurring hormones play a vital role. Exogenous growth regulators are commonly used to induce or enhance blooming, as well as to inhibit or postpone flowering and development (Krishnamoorthy, 2014).

During the off-season, there is a huge market demand for Jasmine (*Jasminum sambac*). The market price during the off-season (December - March) is higher than the remaining part of the year (Krishnamoorthy, 2014). In order to have additional benefit from the crop by maximizing returns throughout the off-season, growth retardants and pruning methods can be adapted to control blooming and increase flower production. It is in this aspect that the possibility of using pruning in combination with plant growth regulators for the regulation of flowering assumes significance. Keeping this in view, the present investigation was taken up with the following objective of evaluation of the effects of growth regulators and pruning on induction of off-season flowering in jasmine (*Jasminum sambac* L.)

Review of literature

2. REVIEW OF LITERATURE

Jasmine is an important commercial loose flower crop in India. Among the major cultivated species, *Jasminum sambac* is ideal for cultivation in Kerala. As there is an ever increasing demand for fresh flowers, efforts are being made to increase the area under jasmine, to develop high yielding varieties and to incorporate improved agro techniques such as pruning and nutrient management in jasmine (Lokhande *et al.*, 2015).

Pruning is an important operation for manipulation of growth and flowering. Regulation of plant growth and flowering is also attained by application of growth regulators. As in the case of any other loose flowers, production of jasmine crop should coincide with the market demand of flowers. Combination of pruning along with the application of growth regulators can influence the time of flower production. Literature pertaining to effect of pruning time and application of growth regulators in flowering of jasmine are reviewed here.

2.1. PRUNING

Pruning in jasmine is considered to be one of the most important crop management practices responsible for flower regulation and production planning. Pruning serves the purpose of forcing the strongest shoot bud to break in growth (Muthuswami *et al.*, 1973). It keeps the jasmine plant in proper shape and size. Judicious pruning serves to allow light and air to reach the centre of the plant. Removal of the wood on which the flowers were produced will encourage the growth of new healthy shoots which bear more flowers than old branches. Pruning in South India during January resulted in maximum flowering output in jasmine (Pal and Mahajan, 2017).

2.1.1 Effect of pruning time on morphological characters

Bal and Gupta (1956) observed more lateral branching and flowering, through pruning the plants during January to February and July months in *Jasminum auriculatum*.

Muthuswamy *et al.* (1973) experimented on pruning of *Jasminum sambac* var. Single Mogra. They reported that the pruning promoted an appreciably large number of new growths (sprouts) and they have found that by pruning different plants in different months of the year (with an interval of six months between two prunings of the sample plant), flowering can be staggered over the whole year as against the unpruned plants.

Pal *et al.* (1980) conducted a pruning experiment on *Jasminum sambac* and *Jasminum auriculatum* where pruning was done in different plant heights (30 cm, 40 cm and 70 cm) and different months starting from November to February. Maximum flower production (578 g/ plant) was observed in *Jasminum sambac* plants pruned in January at a height of 40 cm.

Hugar and Nalawadi (1994) recorded a significantly higher leaf area per plant (11 per cent) in *Jasminum auriculatum* when pruned in the last week of November.

Abdou and Badran (2003) observed that pruning in December resulted in the maximum plant height (156.23 cm) and diameter of lateral branches, whereas pruning in February resulted in the lowest height (85.43 cm) in *Jasminum sambac*.

Sumangala *et al.* (2003) found a longer primary shoot length of 153.3 cm, a greater number of laterals (9.0) per primary shoot and a greater leaf area per shoot (63.6 m^2/shoot) after pruning six-year-old *Jasminum sambac* plants in mid-December.

Chopde *et al*. (2017) recorded that significantly maximum length of primary shoot, leaves per primary shoot and productive shoots per plant were recorded when the *Jasminum sambac* plants were pruned at the 4^{th} week of December. They also observed that sprouts per plant, the weight of 100 flower buds and shelf life of flowers were not influenced by the time of pruning.

Pal (2017) observed that pruning in the last week of January at 45 cm height significantly improved shoot length as well as secondary and tertiary branches in *Jasminum auriculatum.*

Kumar *et al*. (2021) studied the effect of pruning height and pruning time in *Jasminum multiflorum* and reported that pruning at 60 cm height during the last week of September resulted in maximum plant height (148.80 cm) at flowering (90 DAP), pruning during the last week of February resulted in the maximum number of primary branches (25.34) and pruning during the last week of November resulted in the maximum number of secondary branches (176.27).

2.1.2. Effect of pruning time on flower characters and yield

Subramanian (1977) recorded the maximum yield (632.16 g/ plant) in *Jasminum sambac* cv. Jathimallige plants pruned during the second fortnight of December.

Nedumaran (1977) found February and March pruned plants had minimum number of days (23.46 and 24.34) for flower bud initiation in *Jasminum auriculatum*.

Pruning of *Jasminum grandiflorum* at a height of 90 cm recorded highest bud weight (0.31 g), corolla tube length (1.67 cm), total flower length (3.21 cm) and weight of hundred flowers (25 g) (Subramanian and Shanmugavelu, 1980).

Pruning during January at 40 cm height was found to enhance the yield of *Jasminum sambac* cv. Khoya (Pal *et al.*, 1981).

Bhattacharajee (1984) investigated sequential pruning time in *Jasminum grandiflorum* at IIHR Bangalore and observed that when pruning began between 15th December and 5th January flower yield was increased by 13.8 and 28.2 per cent over unpruned plants (control).

According to Pal *et al*. (1981) pruning *Jasminum sambac* plants in January produced more blooms, whereas pruning in November increased the number of flowers per bloom.

Maximum flower yield in *Jasminum auriculatum* was obtained when pruned at 75 cm height where as pruning at 30 cm height was found to enhance flower yield in *Jasminum sambac* (Singh and More, 1980).

Siddagangaiah and Muthapparai (1988) observed less number of days to flowering (28 days) in *Jasminum sambac* plants pruned in October. Duration of flowering was significantly higher in plants pruned in October and November while it was significantly lower in the plants pruned in May and April. Plant yield is significantly higher in December pruned plants (677 g/ plant).

Hugar and Nalawadi (1994) observed significantly higher flower yield (12,424 kg/ ha) in plants pruned during the last week of December in *Jasminum auriculatum*.

According to Sumangala *et al*. (2003), the days taken for initiation of flowering was more in plants pruned in November (46.12 days) and more numbers of flower buds per plant (3921) were noticed in *Jasminum sambac* plants pruned in December.

Nair *et al*. (2009) reported minimum number of days for bud initiation in *Jasminum sambac* plants pruned during September. Longest duration of flowering (175 days) and maximum bud diameter (1.45 cm) was observed in October pruned plants.

Chopde *et al*. (2017) observed a significant increase in flower yield in terms of flower buds per plant (621.25), flower yield per plant (221 g) and flower yield per ha (17.64 q) when the plants were pruned during the 4th week of December at 30 cm above ground level in *Jasminum sambac*.

According to Pal (2017) a maximum number of flowers per plant (751.45), the yield of flower per plant (94.56 g) and maximum flower yield per ha (6.302 q) were recorded in *Jasminum auriculatum* pruned during the last week of January.

Pruning during the last week of October resulted in more plant height (65.18 cm), number of shoots (47.33) and maximum yield (64.24 g/ plant) in *Jasminum auriculatum* whereas, the lowest number of shoots (31.76) and yield (24.59 g/ plant) was observed in December pruning (Khanchana and Jawaharlal, 2019).

Kumar *et al*. (2021) reported September as ideal pruning season and a height of 60 cm from the ground as ideal pruning height to obtain highest yield in *Jasminum multiflorum*.

2.2. EFFECT OF GROWTH REGULATORS

2.2.1. Cycocel

Cycocel is known to retard cell division and cell elongation in shoot tissue and thus regulate the plant height physiologically without causing malformation of leaves and stem. Its trivial name is chloro choline chloride (CCC) and its chemical name is 2-chloroethyl trimethyl ammonium chloride. Cycocel treated crops are more compact with shorter internodes, stronger stems, and greener leaves. The optimum rate of cycocel, timing of application and frequency will vary for different crops (Lindley, 1973).

a. Effect on morphological characters

In *Jasminum grandiflorum,* CCC significantly reduced primary and secondary shoot length. The number of laterals and number of leaves was increased by the foliar application of CCC at 500 ppm (Pappaiah and Muthuswamy, 1977). They also reported similar results in *Jasminum auriculatum* in 1978.

Gowda *et al.* (1991) reported in *Jasminum sambac* that application of CCC at the rate of 500 ppm increased shoots per plant, leaf area per shoot, internodes per shoot, flower bud quality and flower bud yield, length of secondary shoot and a reduction in internodal length.

Sharma and Singh (1991) found that application of CCC at 500 ppm increased number of leaves, internodes per shoot, flower yield and length of secondary shoot in *Jasminum sambac*.

Muradii *et al*. (2003) recorded increased yield (653g/ plant) and reduced internodal length in *Jasminum sambac,* by the application of cycocel at 500 ppm.

Chopde *et al.* (2017) reported in *Jasminum sambac* that the total number of secondary laterals per primary shoot per plant (8.14) were significantly highest in plants treated with 750 ppm cycocel followed by plants treated with 500 ppm cycocel (7.49). The non-treated plants (control) recorded a minimum number of secondary shoots (16) per plant.

Sudhagar and Kamalakannan (2017) observed the highest bud length (2.98 cm), stalk length (2.36 cm), total flower length (2.36 cm), total bud length (5.34 cm) and maximum flower yield (14.1 t/ ha) in jasmine plants treated with cycocel at 1500 ppm.

b. Effect of cycocel on flowering and yield characters

Bhattacharjee (1983) observed an early initiation of flower, reduced corolla tube length (1.05 cm) and increased the number of flowers (734) when cycocel was applied at 1000 ppm in *Jasminum grandiflorum*.

Murali and Gowda (1988) reported that spraying of cycocel at 1000 ppm induced early flowering (20 days), produced higher flower yield (638.38 g/ ha) and longer flower duration (167 days) in *Jasminum multiflorum*.

Gowda (1988) reported that application of cycocel at 1000 and 2000 ppm recorded early flowering. The number of flowers (4645.29/ plant) and yield (5388.52 kg/ ha) were found to increase by application of cycocel at 1000 ppm in *Jasminum sambac*.

Gowda and Gowda (1990) reported early flower initiation (15 days) and long duration of flowering (164 days) with the application of cycocel in *Jasminum multiflorum*.

Application of cycocel 750 ppm was found beneficial for improving diameter of flower buds, longevity of flowers in field and yield of flower buds as well as flowers per plant in *Jasminum sambac*. Minimum flower buds and flower yield plant were noted with the non treated plants (control) (Chopde *et al.,* 2017).

Sudhagar and Kamalakannan (2017) observed that, the application of cycocel at 1500 ppm exerted favourable influence and enhanced the flower bud characteristics *viz*., flower bud length (2.98 cm), flower stalk length (2.36 cm) and total length of the flower (5.34 cm) in *Jasminum grandiflorum*. The yield attribute *viz.*, hundred flower buds weight (9.90 g), flower buds yield per plant (4.23 kg), flower buds yield plot (33.84 kg) and flower buds yield hectare (14.1 t/ ha) were also found to be the maximum in the plants treated with CCC 1500 ppm.

Mundhe *et al.* (2018) reported that pruning in *Jasminum sambac* at 50 cm from ground level resulted significantly superior for flowering parameters like days to initiation of the first flower (49.25 days) and days to 50 per cent flowering (53.48 days), the weight of 100 flowers (21.0 g), the number of flowers per plant (383.85), a yield of flowers per plant (80.19 g), the yield of flowers per plot (16.12 kg) and yield of flowers per hectare (55.97 q/ ha).

c. Effect of cycocel on other flower crops

c.1. Effect on growth and physiological characters

The impact of growth retardants on growth and yield of the African marigold (*tagetes erecta*) was studied by Khandelwal *et al.* (2003), and the application of cycocel at 3000 ppm as foliar spray resulted in reduced plant height (51.77 cm).

Balachandra *et al.* (2004) reported that spray of cycocel at 1000 ppm in ageratum resulted in to reduction of plant height (57.30 cm) and there was production of more number of branches (16.40 per plant) compared to control.

A reduction in leaf area (5.91 cm^2) was noticed in *Dianthus caryophyllus* when plants were treated with cycocel at the concentration of 1000 mg/ L (Ahmad *et al*., 2007).

Kumar (2019) noticed maximum reduction in leaf area (20.72 cm^2) when treated with cycocel at 2500 ppm followed by cycocel at 2000 ppm (21.91 cm^2) in *Nerium odorum* L.

According to Jeevan *et al.* (2020) application of cycocel at 1000 mg/ L 45 days after transplanting proved to be the best treatment for reducing the plant height (24 per cent) and yield improvement (14 per cent) during the rainy season in *Tagetes erecta.*

c.2. Effect on flowering and yield

In marigold, Parmar and Singh (1983) reported that spraying of cycocel at 750 ppm gave maximum flower yield and at 1000 ppm delayed flowering apart from reduction in plant height.

Yadav (1997) studied the effect of cycocel on the growth and flowering of African marigold and reported that spraying with cycocel 750 ppm resulted in the highest flower weight (10.88g/ flower), flower diameter (8.2 cm), the number of flowers (416.23), reduction in the number of branches (8) and early flower emergence (43.68).

Khandelwal *et al.* (2003) found that the application of cycocel at 3000 ppm as foliar spray recorded more number of flowers per plant (67.01) and highest flower yield (186.80 q/ ha) in *Jasminum sambac*.

Pal *et al.* (2014) studied the effect of various plant growth retardants on the growth and flower yield of African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda. Among the treatments, tested, cycocel (400 ppm) decreased the height of the plant but significantly increased the number of flowers, the diameter of flower and total yield of flowers as compared to other treatments.

2.2.2. Gibberellic acid (GA_3)

Gibberellins are the most widely used and proven growth substances in horticulture. These are group of diterpenoid acids, that function as plant growth regulators influencing a range of developmental processing in stem elongation, germination, breaking of dormancy flowering, sex expression, enzyme induction as well as leaf and fruit senescence. Gibberellic acid regulates flower initiation in some long day plants and biennial species and inhibit flowering of some perennials. GA_3 is a major gibberellic acid used for commercial purpose (Sharifuzzaman *et al*., 2011).

a. Effect of GA_3 on morphological characters

Pappaiah and Muthuswamy (1977) reported that the application of 25 to 75 ppm GA_3 significantly increased primary and secondary shoot length in *Jasminum grandiflorum* under Tamil Nadu conditions.

GA_3 at 50 ppm increased the leaf length, leaf width and leaf area in *Jasminum grandiflorum* (Pappaiah and Muthuswamy, 1978). They also reported that GA_3 at 50 and 75 ppm gave highest shoot length (67.2 cm and 85.6 cm) and they also observed the increase in the secondary shoot length and internodal length in *Jasminum auriculatum*.

Application of 100 ppm GA_3 was found to increase shoot length in *Jasminum grandiflorum* (Bhattacharjee, 1983).

According to Murali (1984) maximum leaf size, leaf area, elongation of internodes and enhancement of shoot growth was observed in *Jasminum multiflorum* when treated with different concentrations of GA_3 like 50 ppm, 100 ppm and 150 ppm.

Gowda (1988) reported that the application of GA_3 resulted in improvement of length and width of leaf, leaf area, internodal length and enhancement of shoot growth in *Jasminum sambac*.

Shalaby *et al.* (1989) observed spraying of GA_3 at 1000 ppm on two year old *Jasminum sambac* plants resulted in better plant height (89.7 cm).

b. Effect on flowering and yield characters

Pappaiah and Muthuswamy (1978) reported that application of GA_3 at 75 ppm concentration reported higher corolla tube length and delayed flowering in *Jasminum auriculatum*.

In *Jasminum multiflorum* GA_3 sprayed at 100 ppm delayed onset of flowering and reduced the total duration of flowering (6 days) (Murali, 1984).

Gowda (1988) reported that application of GA_3 at 75 ppm resulted in delayed onset of flowering and also a reduced number of flowers in *Jasminum sambac.*

According to Gowda and Gowda (1990), the duration of flowering (15.45 days) was reduced by GA_3 application at 100 ppm in *Jasminum multiflorum.*

Sridhar (2006) reported that application of GA_3 at 25 ppm and 50 ppm registered the lowest length of flower buds and reduced weight of 100 flower buds (14.12g) with an application of GA_3 at 50 ppm in *Jasminum sambac.*

Sobhana (2014) studied the effect of bioregulators on flower production of jasmine (*Jasminum sambac*) and observed that maximum flower yield during off-season was observed when plants were treated with GA_3 at 20 ppm followed by Cycocel at 1000 ppm.

Al Chalabi *et al.* (2018) found that spraying plants with GA_3 at a concentration of 300 ppm significantly increased the number of flowers, total flower yield (50.52 g) and the volatile oil yield (0.325 g) and the fresh weight for flowers (2.22 g). Spraying of GA_3 at concentration of 150 ppm led to a significant increase in percentage of volatile oil (0.629 percent) and fresh weight for flowers in *Jasminum sambac*.

Among the various treatments earliness in flowering (26.38 DAP), maximum duration of flowering (171.00 days) and a significant increase in flower yield per plant was recorded in GA_3 at 150 ppm with a value of 460.34 and 615.72 g per plant at 90 and 120 DAP respectively (Dhanasekaran, 2018).

c. Effect of GA_3 on other ornamental crops

A significant increase in leaf area was observed when *Gazania rigens* was treated with GA_3 in all levels of treatment, the highest leaf area (50 cm^2) was noticed when treated at the concentration of 100 mg/ L (Zulfiqar *et al.*, 2019).

According to Rani and Singh (2013) an increase in leaf length (65.85 cm), leaf width (1.82 cm), chlorophyll a (0.735 mg/ g FW), chlorophyll b (0.186mg/ g FW), and

total chlorophyll content (0.922 mg/ g) were observed *Polianthes tuberosa* treated with GA_3 at the concentration of 150 ppm.

2.2.3. Paclobutrazol

Paclobutrazol (PBZ) is a plant growth regulator (PGR) and also is a fungicide. Paclobutrazol is a synthetic chemical that inhibits the axial growth of a plant while encouraging root growth. PBZ affects the isoprenoid pathway and alters the levels of plant hormones by inhibiting gibberellin synthesis and increasing cytokinins level and consequent reduction in stem elongation (Davis *et al*., 1988).

a. Effect on morphological and flowering characters

Swaminathan *et al.* (1999) reported that spraying of paclobutrazol at 20 ppm increased the plant height (187.43 cm), number of leaves (321.22) and number of tertiary branches (53) in *Jasminum sambac.* Yield of flowers per plant increased with an increase in the concentration of paclobutrazol from 10 to 30 ppm and maximum yield of flower per plant (598.34 g) was recorded at 20 ppm paclobutrazol.

Masyhudi *et al*. (1999) observed higher concentration of paclobutrazol by soil drenching method, slower the vegetative growth of *Jasminum auriculatum,* resulting in increased production of flowers. The highest production of flowers (498.44g/ plant) was noted in plants drenched with paclobutrazol at 200 ppm.

In *Jasminum multiflorum,* Huang *et al.* (2009) found that inflorescence emerged early (2-4 days than control) and new shoots were shrubby when paclobutrazol was treated at 300 ppm.

Gao *et al*. (2002) observed that paclobutrazol (300 mg/ L) hastened the onset of flowering by four days and increased the flower yield by 12.5 per cent with respect to the non treated plants (control) in *Jasminum sambac*.

Wang *et al.* (2014) showed that paclobutrazol significantly inhibited the new shoot growth and increased the young sprout diameter when compared with the control

treatment. Moreover, the paclobutrazol treatment also reduced the leaf growth, increased chlorophyll content and photosynthetic rate of *Jasminum sambac*.

According to Kumaresan *et al.* (2017), *Jasminum sambac* plants when treated with paclobutrazol at 300 ppm as soil drenching significantly increased flowering parameters such as diameter of flower bud (7.98 mm), corolla tube length (11.08 cm) and weight of 100 flower buds (20.96 g).

b. Effect of paclobutrazol on other ornamental crops

Ahmad (2012) found that *Hibiscus rosa- sinensis* treated with 0.25g/ L paclobutrazol significantly reduced plant height, leaf area and increased chlorophyll content (51.82 SPAD).

According to Suradinata *et al.* (2013), application of paclobutrazol at 3 ppm had smallest leaf area and higher specific leaf area (472.3 cm^2 / g)when compared to control in *Begonia rex-cultorum.*

2.2.4. Mepiquat chloride

Mepiquat chloride is a quaternary ammonium salt consisting of equimolar amounts of mepiquat cations and chloride anions. It is a water-soluble anti gibberellic chemical. As a plant growth regulator, it is used in agriculture to reduce vegetative growth. Its chemical name is 1,1, piperidinium chloride (DPC) and trade name Mepiquat chloride or PIX or DPC (York, 1983; Kerby, 1985).

a. Effect on morphological characters

Kalaimani *et al*. (2016) revealed that in plant spread (73.21 cm), the number of primary branches (12.90) and number of secondary branches (31.90) were significantly increased when pruned during the last week of September followed by foliar spray of mepiquat chloride at 150 ppm, in *Jasminum sambac*.

b. Effect on flower and yield characters

Kalaimani *et al*. (2016) reported that jasmine plants treated with mepiquat chloride at 300 ppm were found to have highest number of buds per cyme (7.70), weight of 100 flower buds (28.00 g), flower yield per plant (222.47 g) and flower yield per ha (1423.81 kg). Flower quality parameters such as the total length of a flower bud (2.64 cm), length of flower bud without corolla tube (1.37 cm), corolla tube length (1.27 cm) and diameter of a flower bud (1.00 cm) were influenced significantly in plants pruned during last week of September along with a foliar spray of mepiquat chloride at 150 ppm.

c. Effect of mepiquat chloride on other crops

Application of mepiquat chloride at 1.0 litres per hectare in cotton at vegetative stage reduced the plant height by 26 cm and increased leaf area by 23 per cent (Varela and Vallejo, 1982).

According to Canore and Prado (1983), application of mepiquat chloride at 0.6 litres per hectare at flowering stage reduced the plant height by 31 cm in cotton.

Prabhu (2000) reported that, application of mepiquat chloride at the rate of 500 and 1000 ppm in black gram significantly reduced the plant height, increased number of leaves as well as dry matter production. He also recorded the maximum number of pods and pod yield for the same treatment.

Matsoukis *et al*. (2015) found that in *Lantana camara* mepiquat chloride at 100 ppm decreased specific leaf area (26 per cent) compared to non-treated plants (control).

Spitzer *et al.* (2018) observed a significant increase in plant height (128. 50 cm), leaf area (900.50 cm^2), leaf area index (4.89 LAI) and total chlorophyll content (1.37 mg/ g) at harvesting stage when treated with mepiquat chloride at the rate of 125 ppm in sunflower.

Studies conducted by Suzuki (2018) in *Helianthus annus* cv. Florenza reported a reduction in plant height by 43.2 cm, leaf area by 47. 9 percent when treated with

mepiquat chloride at the concentration of 10L/ ha. Also observed that the flower head size had a negative correlation with an increase in the concentration of mepiquat chloride. Smallest capitula were observed in plants treated with mepiquat chloride at the rate of 10L/ ha.

Materials and methods

3. MATERIALS AND METHODS

The present study entitled "Induction of off-season flowering in jasmine (*Jasminum sambac* L.)" was carried out at the department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara, Thrissur, during 2020-2021. The materials used and the methodology adopted for the study is presented in this chapter.

3.1 Location of the experiment

Vellanikkara is situated at an altitude of 22.25 m above MSL and 10^0 32' N latitude and $76^0$10' longitude.

3.2. Climate and weather conditions

The location enjoys a humid tropical climate with maximum temperature varying from 25^0C to 39.6^0C and minimum temperature from 17.9^0 C to 27.2^0 C during the period of study. The mean relative humidity varied from 49 to 99 %.

The weather parameters during the experimental period are presented in the appendix.

3.3 Experimental details

The study comprises a combination of two factors *viz.* pruning (factor 1) and growth regulators (factor 2).

This experiment was conducted in one-year-old jasmine plants in the field of the department of Floriculture and Landscape Architecture, College of Agriculture (Plate 1) with three levels of pruning and eight different doses of growth regulators along with control (pruning alone).

3.3.1. Pruning

Pruning treatments were given at three levels.

P_1 - Pruning during the last week of September

P_2 - Pruning during the last week of October

P_3 - Pruning during the last week of November

Three plants per replication were selected and there was two replication. Plants were pruned at a height of 45 cm from the ground level (plate 2).

3.3.2. Growth regulators

Growth regulators were applied on plants only once 15-20 days after pruning. Among the growth regulators Cycocel, Mepiquat chloride and GA_3 were applied by foliar spray and paclobutrazol was applied in the soil by drenching around the root zone (plate 3).

G_1 - Cycocel @ 1000 ppm

G_2 - Cycocel @ 1500 ppm

G_3 - Paclobutrazol @ 200 ppm

G_4 - Paclobutrazol @ 300 ppm

G_5 - Mepiquat chloride @ 150 ppm

G_6 - Mepiquat chloride @ 300 ppm

G_7 - GA_3 @ 100 ppm

G_8 - GA_3 @ 150 ppm

G_9 - Control (Without application of growth regulators)

3.4. Design of experiment

Design of experiment : RBD (with two factors)

Number of treatments : 27 (9×3)

Number of replications : 2

Spacing : 1.25m×1.25m

Pruning in jasmine

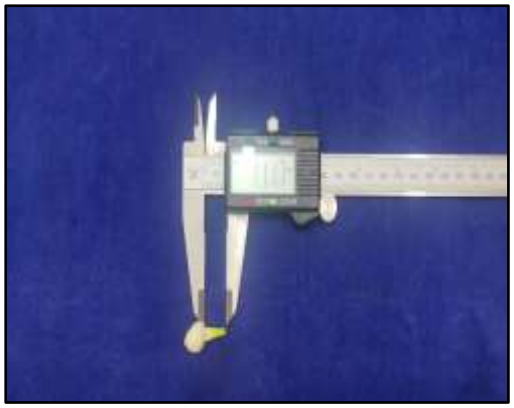
Field layout after pruning

Plate 2. Pruning operation in jasmine

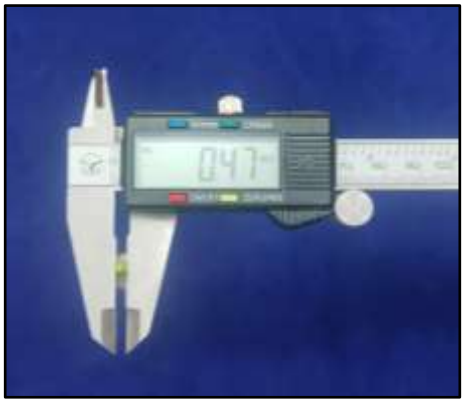
Foliar application of growth regulators

Soil drenching of paclobutrazol

Plate 3. Application of growth regulators



Corolla tube length



Corolla tube girth

Specific leaf area

Growth parameters

Plate 5. Measurement of parameters

No. of plants/ treatment : 6

3.5. Main items of observations made

3.5.1. Growth parameters

a. Plant height

The height of the plant was measured from the base of the tallest shoot to the last node at monthly intervals and the average height was expressed in cm.

b. Plant spread

Plant spread was taken in North-South and East-West direction at monthly intervals and average plant spread was calculated and expressed in cm.

c. Number of primary branches

The number of primary branches were counted after treatment and expressed in numbers.

d. Secondary branches

The number of secondary branches were counted after treatment and expressed in numbers.

3.3.2. Physiological parameters

a. Specific leaf area ($cm^2 g^{-1}$)

Specific leaf area is a measure of leaf area of the plant to leaf dry weight and expressed in cm^2 per gram as proposed by Kvet *et al*. (1971). It was measured in the quarterly interval for each pruning.

$$SLA = \frac{\text{Leaf area } (cm^2)}{\text{Leaf dry weight } (g)}$$

b. Total chlorophyll content (mg g^{-1})

The chlorophyll content of the leaves was calculated using the method suggested by Porra (2002). Fully grown matured leaves were collected and cut into pieces by eliminating the midrib. Hundred mg of this was thoroughly ground using a pestle and mortar and 10 mL of 80% acetone. The ground material was then centrifuged for 10 minutes at 5000 rpm. With a spectrophotometer, the supernatant collected in small vials

was read at 646.6 nm and 663. 6 nm using distilled water as a blank. From the readings chlorophyll a, b and total chlorophyll content were estimated using the formula and expressed in mg/ g fresh weight.

Chlorophyll a = 12.25 ($A_{663.6}$) - 2.55 ($A_{646.6}$) x 10 ml acetone / 100 mg leaf tissue Chlorophyll b = 20.31 ($A_{646.6}$) - 4.91 ($A_{663.6}$) x 10 ml acetone / 100 mg leaf tissue

Total hlorophyll = 17.76 ($A_{646.6}$) + 7.34 ($A_{663.6}$) x 10 ml acetone / 100 mg leaf tissue

3.3.2. Yield and quality parameters

a. Days to bud initiation after treatment

Time taken for the first flower bud to appear after each set of pruning was taken and expressed in the number of days.

b. Number of flower buds per cyme

The number of flower buds per cyme of each plant was taken in the monthly interval.

c. Number of cymes per plant

The number of flower cymes per plant was taken at monthly intervals.

Plate 4. Field during observation period

Plate 1. General view of field

d. Number of flower buds per plant

The total number of flower buds per plant was counted at monthly intervals.

e. Weight of 100 flower buds

The weight of the flower buds harvested in each day was measured and hundred flowers weight was calculated and expressed in grams each month.

f. Flower yield per plant

Freshly opened flowers were harvested every day and weight was taken and expressed in grams in each month.

g. Corolla tube length

The length of the corolla tube in five flowers per plant per month was observed and was expressed in mm.

h. Corolla tube girth

The girth of the corolla tube in five flowers per plant per month was observed and was expressed in mm.

i. Width of flower bud

The width of the flower bud in five flowers per plant per month was taken and expressed in mm.

j. Length of flower bud

The length of the flower bud in five flowers per plant per month was taken and expressed in mm.

h. Flower yield per plant during off-season and peak season

Total flower yields were calculated separately for off-season and peak season at the end of each period.

3.4. Statistical analysis

The data pertaining to growth, yield and quality parameters were subjected to statistical analysis by applying the technique of analysis of variance for Factorial randomised block design. OP stat and google sheets were used to compute the data.

Results

4. RESULTS

The results of the study entitled "Induction of off-season flowering in jasmine (*Jasminum sambac* L.)" which was carried out at the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara, Thrissur are presented in this chapter.

4.1 Growth characters

4.1.1. Plant height (cm)

The time of pruning significantly influenced the growth parameter, plant height during the months of January to June. P_1 (pruning during the last week of September) was found to have the greatest plant height upto April (Table 1). During the month of May, pruning during the last week of September (P_1) and pruning during the last week of October (P_2) were on par in terms of this parameter (101.37 and 94.80 cm respectively). In June plants pruned during the last week of October (P_2) expressed significantly greatest plant height (117.46 cm). Throughout the study period, plants pruned during the last week of November (P_3) recorded the lowest plant height.

Regarding the influence of levels of different growth regulators on plant height, significant difference was only observed during the months of February and March (Table 1). Treatments G_7 (GA_3 100 ppm), G_8 (GA_3 150 ppm), G_1 (Cycocel 1000 ppm), G_4 (paclobutrazol 300 ppm), G_3 (paclobutrazol 200 ppm) and G_9 (control) were on par in terms of plant height (91.17, 88.16, 83.50, 82.08, 80.11, and 77.58 cm respectively) during February. The same trend was observed during March also. Among different levels of growth regulators, G_6 (mepiquat chloride 300 ppm) was found to produce the shortest plants (63.60 cm and 69.66 cm) in February and March respectively.

Effect of interaction of pruning and growth regulators had no significant influence on plant height during the growth period (Table 2).

4.1.2. Plant spread (cm)

The spread of jasmine plant was found to have been significantly influenced by the time of pruning during the months of February and March (Table 2). The plants pruned during last week of September (P_1) and plants pruned during last week of October (P_2) were on par with respect to the plant spread (106.56 and 95.43 cm respectively) in the month of February (Table 3). The plant spread was significantly highest in plants pruned during last week of September (P_1) (116.51 cm) during March.

Growth regulators and the interaction of P x G had no influence on plant spread could be observed during the entire period of observation (Table 3 and 4).

4.1.3. Number of primary branches

The time of pruning and levels of growth regulators and their interaction were found to have no influence on the number of primary branches per plant in jasmine (Table 5 and Table 6).

4.1.4. Number of secondary branches

Time of pruning was found to have no effect on the number of secondary branches per plant (Table 5).

Regarding the influence of growth regulators, significant variation among the treatment was observed and the highest number of secondary branches (12.56) was found in plants treated with G_1 (Cycocel 1000 ppm), followed by G_2 (Cycocel 1500 ppm) (11.55) (Table 5).

The interaction effect of P x G was found to be non-significant for this parameter (Table 6).

4.2. Physiological parameters

4.2.1. Specific leaf area (cm^2/ g)

The physiological parameter, specific leaf area was found not to be influenced significantly by the time of pruning (Table 7).

Table 1. Effect of time of pruning and growth regulators on plant height (cm) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21	May 21	June 21
TIME OF PRUNING	P_1	83.24	90.66	93.80	100.52	101.37	105.37
	P_2	71.04	76.90	81.13	88.07	94.80	117.46
	P_3	64.41	68.64	73.28	80.73	87.96	93.65
CD (0.05)		**10.41**	**9.63**	**10.03**	**10.33**	**7.43**	**11.95**
GROWTH REGULATORS	G_1	77.33	83.50	88.28	96.38	100.12	112.35
	G_2	63.94	68.33	72.55	79.88	91.59	94.05
	G_3	73.39	80.11	84.89	91.58	95.00	103.50
	G_4	70.68	82.08	81.80	87.00	90.51	102.38
	G_5	68.11	74.08	78.64	86.67	90.79	98.72
	G_6	61.36	63.61	69.66	76.47	81.54	95.18
	G_7	85.00	91.17	96.72	103.05	109.61	126.80
	G_8	83.65	88.16	95.05	100.08	103.31	113.35
	G_9	72.61	77.58	77.06	86.86	89.96	103.12
CD (0.05)		**NS**	**16.68**	**17.37**	**NS**	**NS**	**NS**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 2. Effect P x G on plant height (cm) of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21	May 21	June 21
P_1 x G_1	87.83	95.50	103.00	108.50	113.16	115.78
P_1 x G_2	74.67	80.50	85.67	91.66	95.50	98.60
P_1 x G_3	97.00	104.67	112.33	117.17	117.83	121.00
P_1 x G_4	79.13	101.00	94.50	99.33	99.33	102.93
P_1 x G_5	80.67	80.50	87.92	93.75	91.92	95.67
P_1 x G_6	70.58	83.33	78.83	83.76	83.83	86.72
P_1 x G_7	87.33	95.00	102.67	108.33	108.33	115.67
P_1 x G_8	93.00	92.66	107.33	109.08	109.33	113.36
P_1 x G_9	79.00	82.83	72.00	93.17	93.17	98.65
P_2 x G_1	84.50	90.00	93.00	105.65	110.50	140.27
P_2 x G_2	61.00	66.33	70.50	79.16	100.17	102.65
P_2 x G_3	68.17	73.17	77.67	85.16	89.33	108.17
P_2 x G_4	73.17	78.08	81.42	87.50	91.08	118.65
P_2 x G_5	65.33	71.17	74.33	83.00	88.83	93.29
P_2 x G_6	47.50	52.83	56.83	64.33	69.50	110.55
P_2 x G_7	79.00	84.83	88.83	95.67	103.83	139.17
P_2 x G_8	86.17	95.16	100.33	105.50	108.33	128.20
P_2 x G_9	74.50	80.58	87.25	86.66	91.66	116.20
P_3 x G_1	59.67	65.00	68.83	75.00	76.70	81.00
P_3 x G_2	56.17	58.17	61.50	68.83	79.12	80.89
P_3 x G_3	55.00	62.50	64.66	72.42	77.85	81.34
P_3 x G_4	59.75	67.17	69.50	74.17	81.12	85.56
P_3 x G_5	58.33	70.58	73.67	83.25	91.61	98.22
P_3 x G_6	66.00	54.66	73.33	81.33	91.28	97.28
P_3 x G_7	88.67	93.67	98.66	105.17	116.68	125.57
P_3 x G_8	71.80	76.66	77.50	85.66	92.26	98.50
P_3 x G_9	64.33	69.33	71.92	80.75	85.06	94.50
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3. Effect of time of pruning and growth regulators on plant spread (cm) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apri 21	May 21	June 21
TIME OF PRUNING	P_1	95.99	106.56	116.51	118.72	119.58	123.06
	P_2	87.48	95.43	100.61	109.70	113.96	111.14
	P_3	77.89	85.36	89.92	104.89	112.44	98.84
CD (0.05)		**NS**	**16.29**	**15.74**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	101.55	108.18	113.53	121.64	122.39	113.44
	G_2	74.55	85.72	91.22	100.30	112.54	113.78
	G_3	92.86	97.86	102.86	111.37	112.37	111.64
	G_4	79.96	89.72	95.42	104.16	107.74	102.67
	G_5	81.90	91.75	96.57	107.85	109.64	111.34
	G_6	85.89	91.92	104.91	114.43	117.73	110.00
	G_7	91.97	113.86	121.02	126.24	131.53	120.25
	G_8	90.05	95.47	101.94	111.53	117.82	112.29
	G_9	85.39	87.62	93.68	102.48	106.20	103.60
CD (0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 4. Effect of P x G on plant spread (cm) of *Jasminum sambac*.

Treatments	Jan 21	Feb 21	Mar 21	Apr 21	May 21	June 21
P_1 x G_1	109.75	117.17	125.00	130.08	117.58	119.80
P_1 x G_2	92.25	98.25	106.16	110.33	136.00	139.66
P_1 x G_3	119.92	126.33	132.25	136.92	131.42	133.93
P_1 x G_4	85.67	92.25	102.17	107.92	107.92	111.39
P_1 x G_5	103.87	110.92	117.50	123.13	123.13	127.76
P_1 x G_6	101.33	107.92	107.33	117.88	117.88	122.72
P_1 x G_7	57.58	112.83	117.58	119.08	119.08	122.21
P_1 x G_8	99.25	104.91	115.25	122.17	122.17	125.25
P_1 x G_9	94.33	88.50	95.42	101.08	101.08	104.34
P_2 x G_1	115.25	120.13	124.75	132.13	137.38	143.25
P_2 x G_2	58.83	83.50	87.66	95.83	100.92	101.80
P_2 x G_3	94.16	90.25	94.25	102.42	105.83	96.72
P_2 x G_4	82.83	97.83	102.17	108.00	111.92	93.86
P_2 x G_5	71.00	78.00	81.25	92.08	93.13	91.94
P_2 x G_6	62.25	69.58	73.92	99.58	106.17	76.66
P_2 x G_7	113.91	119.33	131.66	130.92	136.16	106.71
P_2 x G_8	103.50	109.50	112.50	121.58	125.50	109.88
P_2 x G_9	85.67	90.79	97.33	104.83	108.67	98.83
P_3 x G_1	79.67	87.25	90.83	102.70	112.22	107.28
P_3 x G_2	72.58	75.41	79.83	94.73	100.70	99.87
P_3 x G_3	64.50	77.00	82.08	94.78	99.87	104.27
P_3 x G_4	71.38	79.08	81.92	96.57	103.40	102.77
P_3 x G_5	70.83	86.33	90.96	108.33	112.68	114.33
P_3 x G_6	94.08	98.25	103.50	125.82	129.16	130.64
P_3 x G_7	104.42	109.41	113.83	128.73	139.34	131.82
P_3 x G_8	67.42	72.00	78.08	90.83	105.81	101.74
P_3 x G_9	76.17	83.58	88.29	101.54	108.84	107.63
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 5. Effect of time of pruning and growth regulators on number of primary branches and number of secondary branches in *Jasminum sambac*

Treatments		Number of primary branches	Number of secondary branches
TIME OF PRUNING	P_1	4.99	8.83
	P_2	4.72	9.04
	P_3	5.35	8.85
CD (0.05)		**NS**	**NS**
GROWTH REGULATORS	G_1	5.03	12.56
	G_2	4.75	11.55
	G_3	4.94	8.83
	G_4	4.63	7.07
	G_5	4.26	6.44
	G_6	5.07	7.44
	G_7	5.44	9.11
	G_8	5.55	8.72
	G_9	5.50	8.44
CD (0.05)		**NS**	**1.72**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 6. Effect of P x G on number of primary branches and number of secondary branches of *Jasminum sambac*

Treatments	Number of primary branches	Number of secondary branches
P_1 x G_1	5.00	12.00
P_1 x G_2	5.75	12.50
P_1 x G_3	5.50	8.00
P_1 x G_4	3.82	6.17
P_1 x G_5	4.30	7.17
P_1 x G_6	6.05	9.83
P_1 x G_7	4.17	8.00
P_1 x G_8	5.00	7.00
P_1 x G_9	5.33	8.83
P_2 x G_1	4.75	13.50
P_2 x G_2	3.49	12.00
P_2 x G_3	4.83	10.00
P_2 x G_4	5.25	7.72
P_2 x G_5	3.50	5.17
P_2 x G_6	3.67	5.50
P_2 x G_7	5.66	8.66
P_2 x G_8	5.33	10.17
P_2 x G_9	6.00	8.67
P_3 x G_1	5.33	12.17
P_3 x G_2	5.00	10.17
P_3 x G_3	4.50	8.50
P_3 x G_4	4.83	7.33
P_3 x G_5	5.00	7.00
P_3 x G_6	5.50	7.00
P_3 x G_7	6.50	10.67
P_3 x G_8	6.33	9.00
P_3 x G_9	5.16	7.83
CD (0.05)	**NS**	**NS**

A significant difference was noticed with levels of growth regulators on specific leaf area.The treatment G_9 (untreated plants) (198.86 cm^2/ g), G_7 (mepiquat chloride 300 ppm) (189.36 cm^2/ g), G_8 (GA_3 100 ppm)(187.85 cm^2/ g), G_5 (mepiquat chloride 150 ppm)(187.66 cm^2/ g), G_3 (paclobutrazol 200 ppm)(184.61 cm^2/ g) and G_4 (paclobutrazol 300 ppm) (183.137 cm^2/ g) found to be on par in terms of this parameter (Table 7).

The interaction effect (Px G) was found to be non-significant for specific leaf area (Table 8).

4.2.2. Chlorophyll a content

The study showed that time of pruning had no influence on the chlorophyll a content of the leaves. But the growth regulators significantly affected this parameter (Table 7). The treatment G_4 (paclobutrazol 300 ppm) and G_3 (paclobutrazol 200 ppm) were found to be on par (Table 7) in terms of this parameter (0.72 mg/g and 0.72 mg/ g respectively).

Effect of P x G was non-significant for chlorophyll a content (Table 8).

4.2.3. Chlorophyll b content

It was noticed that time of pruning, as well as the interaction of pruning and growth regulators, had no influence on the chlorophyll b content of the leaves (Table 7 and 8). But it was influenced by levels of growth regulators. The treatment G_3 (paclobutrazol 200 ppm) (0.45 mg/ g) and G_4 (paclobutrazol 300 ppm) (0.43 mg/ g) were found to be on par with respect to chlorophyll b content of leaves.

4.2.4. Total chlorophyll content

The study showed that pruning and the interaction of P x G have no influence on the total chlorophyll content of leaves. The influence of the growth regulator on the total chlorophyll content was significant. The treatments G_3 (paclobutrazol 200 ppm) (1.29 mg/ g) and G_4 (paclobutrazol 300 ppm) (1.27 mg/ g) were found to be on par for total chlorophyll content of leaves (Table 7 and 8).

Table 7. Effect of time pruning and growth regulators on physiological parameters of *Jasminum sambac*

Treatments		Specific leaf area (cm^2/ g)	Chlorophyll a(mg/g)	Chlorophyll b(mg/g)	Total chlorophyll content (mg/g)
TIME OF PRUNING	P_1	211.29	0.62	0.34	1.07
	P_2	188.14	0.62	0.33	1.06
	P_3	198.38	0.64	0.36	1.1
CD (0.05)		**NS**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	145.76	0.64	0.36	1.14
	G_2	149.56	0.66	0.36	1.16
	G_3	184.61	0.72	0.45	1.28
	G_4	183.14	0.72	0.43	1.27
	G_5	187.66	0.64	0.34	1.12
	G_6	161.17	0.66	0.35	1.12
	G_7	189.36	0.55	0.27	0.88
	G_8	187.85	0.54	0.26	0.88
	G_9	198.86	0.54	0.26	0.85
CD (0.05)		**18.66**	**0.02**	**0.03**	**0.05**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 8. Effect of P x G on physiological parameters of *Jasminum sambac*

Treatments	Specific leaf area (cm^2/ g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll content (mg/g)
P_1 x G_1	208.96	0.64	0.38	1.15
P_1 x G_2	203.86	0.64	0.35	1.13
P_1 x G_3	164.86	0.72	0.45	1.28
P_1 x G_4	137.62	0.71	0.43	1.26
P_1 x G_5	256.71	0.62	0.34	1.11
P_1 x G_6	239.62	0.62	0.33	1.1
P_1 x G_7	190.66	0.56	0.28	0.9
P_1 x G_8	177.4	0.54	0.28	0.88
P_1 x G_9	321.92	0.56	0.25	0.83
P_2 x G_1	207.53	0.62	0.33	1.09
P_2 x G_2	188.29	0.65	0.36	1.16
P_2 x G_3	168.77	0.73	0.44	1.29
P_2 x G_4	113.04	0.71	0.45	1.24
P_2 x G_5	203.25	0.63	0.34	1.12
P_2 x G_6	226.92	0.62	0.33	1.1
P_2 x G_7	156.48	0.55	0.26	0.86
P_2 x G_8	150.62	0.55	0.29	0.9
P_2 x G_9	278.41	0.53	0.25	0.84
P_3 x G_1	193.42	0.67	0.38	1.19
P_3 x G_2	162.15	0.67	0.38	1.2
P_3 x G_3	146.69	0.72	0.46	1.29
P_3 x G_4	162.23	0.75	0.46	1.33
P_3 x G_5	243.39	0.66	0.35	1.13
P_3 x G_6	219.84	0.64	0.38	1.15
P_3 x G_7	196.68	0.55	0.28	0.89
P_3 x G_8	168.06	0.53	0.27	0.86
P_3 x G_9	292.95	0.55	0.27	0.88
CD (0.05)	**NS**	**NS**	**NS**	**NS**

4.3. Flower and yield parameters

4.3.1. Days to bud initiation

From the results, it was evident that time of pruning had a significant influence on the number of days for first flower bud initiation (Table 9). The lowest number of days for flower bud initiation (17.96) was observed in plants pruned during last week November (P_3) whereas plants pruned during last week of September (P_1) took more number of days for bud initiation (25.52).

The effect of levels of growth regulators was significant for days to bud initiation. G_4 (paclobutrazol 200 ppm) (9.01 days) and G_3 (cycocel 1500 ppm) (11.02 days) were the treatments that took least number of days for bud initiation and were on par. They were followed by G_2 (cycocel 1500 ppm) (14.59 days) and G_1 (cycocel 1000ppm) (14.77 days) which were on par. The number of days for bud initiation ranged from 9.05 days to 44.51 days. The plants which were not sprayed with GR (control) took more days for bud initiation (Table 9).

P x G interaction effect had a significant effect on the number of days taken for bud initiation. Treatments P_2 x G_3 (pruning during last week of October along with paclobutrazol 200 ppm), P_1 x G_3 (pruning during last week of September along with drenching of paclobutrazol at 200 ppm), P_2 x G_4 (Pruning during last week of October along with paclobutrazol 300 ppm), P_3 x G_3 (Pruning during last week of November along with paclobutrazol 200 ppm), P_3 x G_4 (Pruning during last week of November along with paclobutrazol 300 ppm), P_1 x G_4 (Pruning during last week of September along with drenching of paclobutrazol 300 ppm), P_2 x G_2 (Pruning during last week of October along with cycocel 1500 ppm) and P_2 x G_1 (pruning during last week of October along with spraying of cycocel 1000 ppm) were found to be on par (13.5, 12.16,, 11.38,11.5,10.16, 10.16 and 8.66 and 8.33 days respectively). The days for bud initiation ranged from 8.33 days to 59.33 days. The treatment combination P_1 x G_8 (pruning during last month of September along with spraying of GA_3 150 ppm), P_1 x G_9 (pruning during last month of September without treatment of growth regulators) took highest number of days for bud initiation (Table 9).

Table 9. Effect of time of pruning and growth regulators on days to bud initiation of *Jasminum sambac*

Treatments		Days to bud initiation
TIME OF PRUNING	P_1	25.52
	P_2	22.74
	P_3	17.96
CD (0.05)		**2.1**
GROWTH REGULATORS	G_1	14.78
	G_2	14.59
	G_3	9.05
	G_4	11.02
	G_5	20.72
	G_6	22.05
	G_7	28.78
	G_8	33.16
	G_9	44.51
CD (0.05)		**3.63**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 10. Effect of P x G on days to bud initiation of *Jasminum sambac*

Treatments	Days to bud initiation
P_1 x G_1	15.83
P_1 x G_2	16.12
P_1 x G_3	8.67
P_1 x G_4	11.39
P_1 x G_5	21.50
P_1 x G_6	21.50
P_1 x G_7	32.67
P_1 x G_8	42.66
P_1 x G_9	59.33
P_2 x G_1	13.50
P_2 x G_2	12.17
P_2 x G_3	8.33
P_2 x G_4	10.17
P_2 x G_5	20.83
P_2 x G_6	22.33
P_2 x G_7	29.83
P_2 x G_8	36.83
P_2 x G_9	50.71
P_3 x G_1	15.00
P_3 x G_2	15.50
P_3 x G_3	10.17
P_3 x G_4	11.50
P_3 x G_5	19.83
P_3 x G_6	22.33
P_3 x G_7	23.83
P_3 x G_8	20.00
P_3 x G_9	23.50
CD (0.05)	**6.29**

4.3.2. Number of cymes per plant

Pruning time had a significant influence on the number of cymes per plant in the months of February to April and it was non-significant in the month of January (Table 11). Plants pruned during last week of November (P_3) showed on par with plants pruned during last week of September (P_1) and recorded highest number of cymes per plant (60.33 and 55.55) during the month of February. Lowest number of cymes per plant was observed in plants pruned during last week of October (P_2) throughout the period of observation. In the month of March and April plants pruned with treatment P_3 showed significantly highest number of cymes per plant (80.66 and 74.34 respectively).

Growth regulators had a significant influence on the number of cymes per plant throughout the study period (Table 11). G_1 (cycocel 1000 ppm) (65.16, 74.55, 90.61 and 78.29 respectively) and G_3 (Paclobutrazol 200 ppm) (56.86, 67.83, 76.30 and 73.80 respectively) were found to be on par throughout the experiment period along with G_7 (GA_3 100 ppm) during January (49.11) and February (60.44). From February to April G_4 also was found to be on par with these treatments (57.44, 71.75 and 66.25 respectively) and during February and April, G_5 (66.25) also found to be promising.

When P x G interaction was studied, it was found to have a significant influence on the yield parameter *viz*. number of cymes per plant during the months of January and April. In January the number of cymes per plant ranged from 9.67 to 87.83 and in April it ranged from 12.95 to 96.88. During the month of January, P_1 x G_1 (pruning during last week of September along with cycocel 1000 ppm), P_1 x G_3 (pruning during last week of October along with paclobutrazol 200 ppm), P_1 x G_3 (pruning during last week of September along with paclobutrazol 200 ppm), P_3 x G_1 (pruning during last week of November along with cycocel 1000 ppm), P_2 x G_1 (pruning during last week of October along with cycocel 1000 ppm), P_1 x G_6 (pruning during last week of September along with mepiquat chloride 150 ppm), P_2 x G_5 (pruning during last week of October along with mepiquat chloride 150 ppm), and P_3 x G_3 (pruning during last week of November along with paclobutrazol 200 ppm) were found to be on par (87.83, 73.33, 65.16, 61.41, 56.85, 57.16, 57.08 and 56 respectively) with respect to number of cymes per plant.

During the month of April P_3 x G_4 (pruning during last week of November along with paclobutrazol 200 ppm), P_1 x G_1 (pruning during last week of September along with cycocel 1000 ppm), P_3 x G_5 (pruning during last week of November along with mepiquat chloride 150 ppm), P_3 x G_1 (pruning during last week of November along with cycocel 1000 ppm), P_3 x G_8 (pruning during last week of November along with GA_3 150 ppm), P_3 x G_3 (pruning during last week of November along with paclobutrazol 200 ppm), P_1 x G_3 (pruning during last week of September along with paclobutrazol 200 ppm), P_3 x G_7 (pruning during last week of November along with GA_3 100 ppm) and P_3 x G_6 (pruning during last week of November along with mepiquat chloride 300 ppm) found to be on par (98.25, 96.88, 91.75, 82.33, 82.16, 81.91, 79.83, 77.5 and 76.16 respectively) (Table 12).

4.3.3. Number of buds per plant

During the initial month of observation, time of pruning had no significance in the number of buds per plant (Table 13). During February, March and April pruning during last week of November (P_3) had the highest number of buds per plant (226.92, 297.67 and 260.31 respectively) and along with this treatment in February plants pruned during last week of September (P_1) also produced highest number of buds per plant (204.42). Throughout the study, plants pruned during October (P_2) showed the lowest number of buds per plant (162.51, 166.89 and 132.08 respectively).

There was a significant difference in the number of buds per plant when treated with growth regulators. Throughout study period (January to April) G_1 (cycocel 1000 ppm) (236, 277.44, 324.77 and 266.77) and G_3 (paclobutrazol 200 ppm) (203.44, 249.58, 283.44 and 261.71) were found to be significant. G_4 (paclobutrazol 300 ppm) in the months of February (208.99), March (265.44) were on par with G_1 (cycocel 1000 ppm) and G_3 (paclobutrazol 200 ppm). G_5 (mepiquat chloride 150 ppm) was found to be on par with G_1 (cycocel 1000 ppm) and G_3 (paclobutrazol 200 ppm) in the months of February (208.77), March (252.44) and April (215.77). G_7 (GA_3 100 ppm) also was found to be on par in the months January (178.71) and February (209.22) (Table 13). During the initial months, G_8 (GA_3 150 ppm) was found to have the lowest value (95.82,

Table 11. Effect of time of pruning and growth regulators on number of cymes per plant in *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P1	47.00	55.55	62.24	57.23
	P2	35.37	45.89	45.73	41.76
	P3	42.39	60.33	80.66	74.35
CD (0.05)		**NS**	**11.15**	**11.69**	**9.52**
GROWTH REGULATORS	G1	65.16	74.55	90.61	78.29
	G2	32.41	39.30	53.05	50.05
	G3	56.86	67.83	76.30	73.80
	G4	29.44	57.44	71.75	66.25
	G5	45.58	55.89	68.67	66.25
	G6	42.86	52.11	59.00	55.66
	G7	49.11	60.44	66.83	60.00
	G8	26.11	38.72	46.06	44.22
	G9	26.72	39.03	33.64	25.47
CD (0.05)		**18.66**	**19.31**	**20.24**	**16.49**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 12. Effect of P x G on number of cymes per plant in *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	87.83	95.17	108.50	96.88
P_1 x G_2	27.83	34.17	55.83	45.33
P_1 x G_3	73.33	80.50	86.33	79.83
P_1 x G_4	48.67	53.83	65.66	50.66
P_1 x G_5	36.25	46.33	55.00	51.00
P_1 x G_6	57.08	67.17	66.00	66.50
P_1 x G_7	40.00	50.67	51.83	53.83
P_1 x G_8	9.67	17.33	22.00	23.00
P_1 x G_9	42.33	54.83	49.00	48.00
P_2 x G_1	57.17	65.66	73.66	55.66
P_2 x G_2	36.08	40.42	44.17	42.17
P_2 x G_3	61.42	66.50	63.16	59.66
P_2 x G_4	35.00	56.50	53.33	49.83
P_2 x G_5	56.00	53.25	56.25	56.00
P_2 x G_6	24.83	28.83	28.33	24.33
P_2 x G_7	42.67	60.66	47.67	48.67
P_2 x G_8	27.00	27.00	31.50	27.50
P_2 x G_9	13.17	14.17	13.50	12.00
P_3 x G_1	65.16	62.83	89.66	82.33
P_3 x G_2	32.41	43.33	59.16	62.66
P_3 x G_3	56.86	56.50	79.42	81.92
P_3 x G_4	29.44	62.00	96.25	98.25
P_3 x G_5	45.58	68.08	94.75	91.75
P_3 x G_6	42.86	60.33	82.66	76.16
P_3 x G_7	49.11	70.00	101.00	77.50
P_3 x G_8	26.11	71.83	84.67	82.17
P_3 x G_9	26.72	48.08	38.42	16.42
CD (0.05)	**32.32**	**Ns**	**Ns**	**28.36**

Table 13. Effect of time of pruning and growth regulators on number of buds per plant of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	169.00	204.42	229.63	186.46
	P_2	128.45	162.51	166.89	132.08
	P_3	154.27	226.92	297.67	260.31
CD (0.05)		**NS**	**41.63**	**43.35**	**29.85**
GROWTH REGULATORS	G_1	236.00	277.44	324.77	266.77
	G_2	115.50	149.41	196.25	164.25
	G_3	203.44	249.58	283.44	261.71
	G_4	105.94	209.00	265.44	208.48
	G_5	167.25	208.78	252.44	215.78
	G_6	155.66	189.53	217.03	183.53
	G_7	178.72	209.22	247.39	194.61
	G_8	95.83	143.17	171.69	158.49
	G_9	96.83	145.44	124.11	82.95
CD (0.05)		**67.55**	**72.06**	**75.08**	**51.69**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 14. Effect of P x G on number of number of buds per plant of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	313.16	350.83	398.83	311.83
P_1 x G_2	96.50	126.33	206.17	148.67
P_1 x G_3	258.00	293.50	319.00	293.73
P_1 x G_4	175.83	199.67	243.66	151.77
P_1 x G_5	131.67	174.92	203.25	187.25
P_1 x G_6	211.67	241.08	243.58	197.58
P_1 x G_7	145.67	186.33	189.17	150.84
P_1 x G_8	34.00	62.17	81.83	79.23
P_1 x G_9	154.50	205.00	181.17	157.28
P_2 x G_1	211.00	249.33	259.33	191.33
P_2 x G_2	126.50	151.58	158.75	147.75
P_2 x G_3	222.83	242.58	232.67	202.73
P_2 x G_4	40.00	205.25	197.58	153.58
P_2 x G_5	206.75	192.00	206.75	170.25
P_2 x G_6	86.83	104.33	105.50	75.00
P_2 x G_7	155.66	169.33	177.17	132.17
P_2 x G_8	99.50	97.00	115.75	78.75
P_2 x G_9	47.00	51.17	48.50	37.15
P_3 x G_1	183.83	232.16	316.16	297.16
P_3 x G_2	123.50	170.33	223.83	196.33
P_3 x G_3	129.50	212.67	298.67	288.67
P_3 x G_4	142.00	222.08	355.08	320.08
P_3 x G_5	163.33	259.42	347.33	289.83
P_3 x G_6	168.50	223.17	302.00	278.00
P_3 x G_7	234.83	272.00	375.83	300.83
P_3 x G_8	154.00	270.33	317.50	317.50
P_3 x G_9	89.00	180.17	142.67	54.42
CD	**117.002**	**NS**	**NS**	**89.54**

143.16 and 171.69) and G_9 (control) showed the lowest number of buds during the month of April (82.94).

It was evident that the P x G interaction had a significant effect on the number of buds per plant in the months of January and April. In month of January P_1 x G_1 (pruning during last week of September along with cycocel 1000 ppm) (313.16), P_1 x G_3 (pruning during last week of September along with paclobutrazol 100 ppm) (258), P_3 x G_7 (pruning during last week of November along with GA_3 100 ppm) (234.83), P_2 x G_1 (pruning during last week of October along with cycocel 1000 ppm) (211) and P_2 x G_5 (pruning during last week of October along with cycocel at mepiquat chloride 50 ppm) (206.75) were found to be on par. In the month of April, all treatments except P_3 x G_2 (pruning during the last week of November along with cycocel 1500 ppm) and P_3 x G_9 (pruning during the last week of November alone) were found to be significant among P_3 x G combinations and was on par with P_1 x G_1 (pruning during last week of September along with cycocel 1000 ppm) (311.83), P_1 x G_3 (pruning during last week of September along with paclobutrazol 100 ppm) (293.73) (Table 14).

4.3.4. Weight of 100 flowers (g)

Time of pruning and interaction of P x G had no significant influence on the weight of 100 flowers (Table 15).

Weight of 100 flowers was significantly affected by the application of different levels of growth regulators. During the period January to April except in February, G_7 and G_8 were on par and superior with respect to weight of 100 flowers and in February G_7 recorded highest value in terms of this parameter. The lowest weight of 100 flowers is observed in G_9 (control) throughout the month of observation (Table 15).

4.3.5. Flower yield per plant (g)

The data revealed that time of pruning had a significant influence on flower yield per plant during the months of February, March and April. Flower yield of plants under plants pruned during last week of September (P_1) (42.8 g) was on par with P_3 (pruning during the last week of November) (48.93 g) in the month of January. In the

Table 15. Effect of growth regulators on weight of 100 flowers (g) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	23.63	23.68	23.65	23.64
	P_2	23.72	23.63	23.66	23.74
	P_3	23.70	23.70	23.29	23.53
CD (0.05)		**NS**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	23.89	23.50	23.89	23.25^b
	G_2	23.74	24.11	23.69	23.62^b
	G_3	22.32	21.77	22.17	22.50
	G_4	22.1	22.42	21.69	22.48
	G_5	23.57	23.44	23.69	23.64
	G_6	23.39	23.36	23.42	23.25
	G_7	26.27	26.67	26.33	26.13
	G_8	26.39	26.00	26.33	26.72
	G_9	21.55	21.78	20.61	21.16
CD (0.05)		**0.69**	**0.64**	**1.43**	**0.95**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 16. Effect of P x G on weight of 100 (g) flowers of *Jasminum sambac.*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	23.50	23.17	24.00	23.58
P_1 x G_2	24.17	24.50	23.66	24.12
P_1 x G_3	22.00	21.66	22.17	22.83
P_1 x G_4	22.00	22.33	21.58	22.43
P_1 x G_5	23.17	23.75	23.67	23.50
P_1 x G_6	24.17	23.25	23.25	22.92
P_1 x G_7	25.50	26.83	26.17	25.25
P_1 x G_8	27.16	25.83	26.50	26.83
P_1 x G_9	21.00	21.83	21.83	21.33
P_2 x G_1	23.17	23.67	23.83	23.33
P_2 x G_2	24.50	23.83	23.58	23.92
P_2 x G_3	21.66	21.50	21.83	21.83
P_2 x G_4	22.33	22.50	21.92	22.92
P_2 x G_5	23.75	23.17	23.67	23.75
P_2 x G_6	23.25	23.50	23.67	23.42
P_2 x G_7	26.83	26.67	26.50	26.50
P_2 x G_8	25.83	26.00	26.17	26.50
P_2 x G_9	21.83	21.83	21.83	21.50
P_3 x G_1	24.00	23.67	23.83	22.83
P_3 x G_2	23.50	24.00	23.83	22.83
P_3 x G_3	22.83	22.17	22.50	22.83
P_3 x G_4	21.50	22.42	21.51	22.08
P_3 x G_5	23.67	23.42	23.75	23.67
P_3 x G_6	23.33	23.33	23.33	23.42
P_3 x G_7	26.50	26.50	26.33	26.66
P_3 x G_8	26.17	26.17	26.33	26.53
P_3 x G_9	21.83	21.67	18.17	20.67
CD (0.05)	**NS**	**NS**	**NS**	**NS**

month of March and April plants pruned in November (P_3) showed significantly higher flower yield (58.21 and 57.92 g respectively) (Table 17).

It was found that growth regulators had a significant influence on flower yield throughout the period of observation (Table 17). G_1 (cycocel at 1000 ppm) (56. 56, 59.55, 53.49 and 55.35 g), G_3 (paclobutrazol at 200 ppm) (42.13, 48.32, 45.41 and 53.01 g) and G_7 (GA_3 at 100 ppm) (41.10, 46.5, 51.66 and 47.3 g) were on par from January to April. Treatments *viz.* G_6 (Mepiquat chloride 300 ppm) in February, G_4 (paclobutrazol 300 ppm), G_5 (mepiquat chloride 150 ppm) and G_8 (GA_3 150 ppm) in March as well as G_5 in April found to be on par with these treatments and recorded highest flower yield per plant (49.03 g, 44.49 g, 45.96 g, 38.94 g, 45.95 g respectively). G_8 (GA_3 150 ppm) showed the lowest flower yield in the month of January (19.71 g) and in the later months (February, March and April), G_9 (control) expressed the lowest flower yield (28.02, 20.25 and 15. 21 g respectively).

The results revealed that the interaction effect of P x G showed a significant difference in the month of February to April. In the month of February P_1 x G_1 (pruning during the last week of September along with cycocel 1000 ppm) (74.67 g), P_1 x G_3 (pruning during the last week of September along with paclobutrazol 200 ppm) (61.95 g), P_2 x G_1 (pruning during the last week of October along with cycocel 1000 ppm) (56.99 g), P_2 x G_6 (pruning during the last week of October along with mepiquat chloride 300 ppm) (50.09 g), P_3 x G_7 (pruning during the last week of November along with GA_3 100 ppm) (70.98 g) and P_3 x G_8 (pruning during the last week of November along with GA_3 150 ppm) (65.93 g) were found to be on par. P_3 x G_7 (pruning during the last week of November along with GA_3 100 ppm) (85.88 g) and P_3 x G_8 (pruning during the last week of November along with GA_3 150 ppm) (80.04 g) were on par in the month of March. In April P_3 x G_1 (pruning during the last week of November along with cycocel 1000 ppm) (61.72 g), P_3 x G_4 (pruning during the last week of November along with paclobutrazol 200 ppm) (65.47 g), P_3 x G_5 (pruning during the last week of November along with mepiquat chloride 150 ppm) (64.74 g), P_3 x G_6 (pruning during the last week of November along with mepiquat chloride 300 ppm) (62.05 g), P_3 x G_7 (pruning during the last week of November along with GA_3 100 ppm) (74.29 g) and P_3

Table 17. Effect of time of pruning and growth regulators on flower yield per plant of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	39.04	42.80	36.39	37.38
	P_2	33.56	35.38	29.22	28.45
	P_3	33.68	48.94	58.21	57.92
CD (0.05)		**NS**	**8.55**	**9.00**	**7.09**
GROWTH REGULATORS	G_1	56.56	59.55	53.49	55.35
	G_2	28.98	33.87	33.94	34.26
	G_3	42.13	48.32	45.41	53.00
	G_4	35.51	40.79	44.49	42.89
	G_5	36.37	43.16	45.96	45.95
	G_6	39.21	49.03	37.34	37.49
	G_7	41.10	46.50	51.66	47.30
	G_8	19.17	32.11	38.94	39.82
	G_9	19.82	28.02	20.25	15.21
CD (0.05)		**16.60**	**14.81**	**15.59**	**12.27**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 18. Effect of P x G on flower yield per plant of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	56.55	74.67	56.35	60.80
P_1 x G_2	28.15	30.50	38.80	32.32
P_1 x G_3	56.58	61.95	46.92	57.46
P_1 x G_4	34.61	42.31	38.88	31.78
P_1 x G_5	29.46	36.28	41.77	37.94
P_1 x G_6	47.50	47.99	26.93	35.02
P_1 x G_7	34.12	35.68	31.79	35.60
P_1 x G_8	9.55	14.21	18.33	17.35
P_1 x G_9	33.88	41.59	27.76	28.19
P_2 x G_1	48.57	56.99	50.44	43.55
P_2 x G_2	28.87	37.93	28.22	30.29
P_2 x G_3	40.41	41.46	34.20	41.62
P_2 x G_4	42.50	35.64	30.92	31.41
P_2 x G_5	41.78	40.08	31.49	35.16
P_2 x G_6	20.40	50.09	23.85	15.41
P_2 x G_7	41.72	32.84	37.31	32.01
P_2 x G_8	24.24	16.20	18.45	19.61
P_2 x G_9	13.53	7.20	8.11	7.02
P_3 x G_1	43.55	46.98	53.70	61.72
P_3 x G_2	29.92	33.19	34.79	40.18
P_3 x G_3	29.41	41.54	55.13	59.93
P_3 x G_4	29.43	44.42	63.66	65.47
P_3 x G_5	37.86	53.13	64.62	64.74
P_3 x G_6	49.73	48.99	61.24	62.05
P_3 x G_7	47.47	70.98	85.88	74.29
P_3 x G_8	23.72	65.93	80.04	82.50
P_3 x G_9	12.04	35.26	24.87	10.42
CD (0.05)	**NS**	**25.65**	**11.24**	**21.26**

x G_8 (pruning during the last week of November along with GA_3 150 ppm) (82.50 g) were found to be on par and recorded highest flower yield per plant.

4.3.6. Length of flower bud (mm)

When studied, the effect of time of pruning on length of flower bud showed a significant influence only in the month of March (Table 19). P_1 (pruning during the last week of September) showed significantly higher value for length of flower bud (11.44 mm) in jasmine plants, which was followed by P_3 (pruning during last week of November) and P_2 (pruning during last week of October), that were on par (11.14 and 11.11 mm respectively) (Table 19).

The growth regulator application had significant effect on the length of flower bud only in the month of February. In the month of February except for G_9 (Control), all treatments were on par and recorded more length of flower bud (G_1 -11.26, G_2 - 11.11, G_3 - 11.25, G_4 - 11.21, G_5 - 11.16, G_6 - 11.27, G_7 - 11.25 and G_8 - 11. 12) (Table 19).

Regarding the interaction effect, no significant difference was observed in terms of this parameter (Table 20).

4.3.7. Width of flower bud (mm)

The individual effect of time of pruning and application of growth regulators and the interaction effect of P x G were found to be non-significant in terms of this parameter (Table 21 and 22).

4.3.8. Corolla tube length (mm)

When the effect of time of pruning on corolla tube length was studied, it was found to have no specific influence on the parameter (Table 23).

The influence of growth regulators in the month of January, G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm), G_8 (GA_3 150 ppm) and G_2 (paclobutrazol 200 ppm) were found to be on superior with respect to this parameter throughout the period of observation(11.49, 11.46, 11.15 and 10.96 mm respectively). However, G_1 (cycocel at

Table 19. Effect of time of pruning and growth regulators on length of flower bud (mm) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	12.22	11.26	11.44	11.19
	P_2	11.15	11.04	11.11	11.25
	P_3	11.05	11.11	11.14	11.25
CD (0.05)		**NS**	**NS**	**0.16**	**NS**
GROWTH REGULATORS	G_1	11.30	11.26	11.37	11.15
	G_2	11.51	11.11	11.34	11.42
	G_3	13.81	11.25	11.42	11.16
	G_4	11.11	11.21	11.08	11.13
	G_5	11.19	11.16	11.18	11.16
	G_6	11.13	11.27	11.17	11.11
	G_7	11.17	11.15	11.14	11.19
	G_8	11.13	11.08	11.12	11.24
	G_9	10.94	10.72	11.26	11.52
CD (0.05)		**NS**	**0.32**	**NS**	**NS**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 20. Effect of P x G on length of flower bud (mm) of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	11.87	11.54	11.84	11.26
P_1 x G_2	12.12	10.98	11.55	11.33
P_1 x G_3	11.00	11.47	11.72	11.07
P_1 x G_4	11.26	11.48	11.12	11.23
P_1 x G_5	11.15	11.26	11.58	11.10
P_1 x G_6	11.23	11.64	11.28	10.98
P_1 x G_7	11.17	11.38	11.23	11.21
P_1 x G_8	11.20	11.57	11.23	10.99
P_1 x G_9	11.03	10.01	11.43	11.58
P_2 x G_1	11.08	11.21	11.22	10.96
P_2 x G_2	11.26	11.02	11.23	11.72
P_2 x G_3	11.28	11.09	11.22	11.28
P_2 x G_4	11.07	10.96	10.96	11.22
P_2 x G_5	11.16	11.13	10.99	10.96
P_2 x G_6	11.09	11.01	11.10	11.23
P_2 x G_7	11.24	11.05	11.21	11.21
P_2 x G_8	11.13	10.88	10.96	11.55
P_2 x G_9	11.04	11.03	11.14	11.14
P_3 x G_1	10.94	11.04	11.07	11.23
P_3 x G_2	11.15	11.35	11.26	11.22
P_3 x G_3	11.16	11.19	11.33	11.14
P_3 x G_4	11.00	11.20	11.16	10.96
P_3 x G_5	11.25	11.10	10.96	11.43
P_3 x G_6	11.08	11.18	11.14	11.12
P_3 x G_7	11.10	11.03	10.98	11.16
P_3 x G_8	11.05	10.81	11.19	11.19
P_3 x G_9	10.75	11.14	11.21	11.84
CD (0.05)	**NS**	**NS**	**NS**	**NS**

Table 21. Effect of time of pruning and growth regulators on width of flower (mm) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	7.22	7.30	7.26	7.13
	P_2	7.13	7.14	7.13	7.18
	P_3	7.11	7.12	7.14	7.22
CD (0.05)		**NS**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	6.98	7.11	7.14	7.09
	G_2	7.30	7.08	7.16	7.07
	G_3	7.08	7.68	7.18	7.13
	G_4	7.06	7.33	7.17	7.34
	G_5	7.20	7.20	7.16	7.21
	G_6	7.11	7.12	7.20	7.28
	G_7	7.23	7.20	7.26	7.17
	G_8	7.36	7.41	7.27	7.35
	G_9	7.15	7.18	7.13	7.13
CD (0.05)		**NS**	**NS**	**NS**	**NS**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 22. Effect of P x G on width of flower bud (mm) of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	6.95	7.12	7.33	6.96
P_1 x G_2	7.46	6.95	7.21	7.16
P_1 x G_3	7.34	7.23	7.35	7.03
P_1 x G_4	7.15	7.43	7.02	7.35
P_1 x G_5	7.12	7.11	7.20	7.02
P_1 x G_6	6.91	7.48	7.43	7.37
P_1 x G_7	7.38	7.53	7.37	7.06
P_1 x G_8	7.48	7.61	7.36	7.07
P_1 x G_9	7.23	7.25	7.13	7.20
P_2 x G_1	6.95	7.17	7.07	7.26
P_2 x G_2	7.20	7.09	7.24	7.29
P_2 x G_3	7.18	7.10	6.96	6.95
P_2 x G_4	6.83	7.36	6.95	7.33
P_2 x G_5	7.38	7.38	7.26	7.36
P_2 x G_6	6.96	6.72	7.06	7.13
P_2 x G_7	7.21	6.97	7.34	7.24
P_2 x G_8	7.24	7.25	7.29	7.03
P_2 x G_9	7.19	7.24	7.03	7.07
P_3 x G_1	7.05	7.05	7.04	7.04
P_3 x G_2	7.25	7.20	7.03	7.23
P_3 x G_3	6.74	6.88	7.24	7.25
P_3 x G_4	7.20	7.20	7.35	7.34
P_3 x G_5	7.11	7.11	7.02	7.24
P_3 x G_6	7.17	7.17	7.11	7.35
P_3 x G_7	7.09	7.09	7.07	7.21
P_3 x G_8	7.37	7.37	7.16	7.02
P_3 x G_9	7.04	7.04	7.23	7.11
CD (0.05)	**NS**	**NS**	**NS**	**NS**

Table 23. Effect of time of pruning and growth regulators on corolla tube length (mm) of *Jasminum sambac*

Treatments		January	February	March	April
TIME OF PRUNING	P_1	11.06	11.19	11.15	11.11
	P_2	10.94	11.17	10.93	10.90
	P_3	11.01	10.97	10.93	11.01
CD		**NS**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	11.49	11.29	11.50	10.89
	G_2	11.46	11.35	11.96	11.68
	G_3	10.96	11.05	11.47	10.83
	G_4	10.59	11.09	10.74	11.07
	G_5	10.35	11.13	10.85	11.21
	G_6	10.91	11.17	11.20	10.86
	G_7	10.93	10.93	11.09	11.21
	G_8	11.15	11.11	10.96	10.73
	G_9	10.22	10.87	10.57	10.58
CD (0.05)		**0.50**	**0.08**	**0.38**	**0.38**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 24. Effect of P x G on corolla tube length (mm) of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	11.39	11.08	11.21	10.37
P_1 x G_2	11.59	11.12	10.91	10.89
P_1 x G_3	10.94	10.73	11.39	10.62
P_1 x G_4	10.46	11.11	10.53	11.51
P_1 x G_5	10.01	11.45	10.97	11.03
P_1 x G_6	10.40	11.40	11.51	11.70
P_1 x G_7	11.28	11.17	11.93	10.89
P_1 x G_8	11.73	11.76	11.94	11.85
P_1 x G_9	11.81	11.01	9.98	10.97
P_2 x G_1	11.79	11.51	11.70	10.91
P_2 x G_2	10.98	11.12	11.09	10.78
P_2 x G_3	10.97	11.44	11.49	11.17
P_2 x G_4	10.07	11.11	10.44	11.47
P_2 x G_5	10.48	10.99	10.78	11.61
P_2 x G_6	11.31	11.25	10.62	10.44
P_2 x G_7	11.15	11.28	10.89	11.21
P_2 x G_8	10.80	11.15	10.24	10.53
P_2 x G_9	10.96	10.72	11.17	9.98
P_3 x G_1	10.28	11.29	11.61	11.39
P_3 x G_2	11.72	11.82	10.89	11.35
P_3 x G_3	10.61	10.98	11.52	10.71
P_3 x G_4	11.25	11.04	10.37	10.24
P_3 x G_5	10.77	10.57	10.80	11.49
P_3 x G_6	11.03	10.87	11.47	10.44
P_3 x G_7	10.65	10.35	10.44	11.52
P_3 x G_8	10.83	10.93	10.71	10.58
P_3 x G_9	10.60	10.90	10.58	10.80
CD (0.05)	**0.50**	**0.21**	**0.38**	**0.38**

1000 ppm) and G_8 (GA_3 150 ppm) in January, as well as G_1 (cycocel at 1000 ppm) in February, was also found to be on par with these treatments with respect to this parameter. G_9 (control) showed the lowest corolla tube length throughout the period of study (10.22, 10.87, 10.57 and 10.58 mm respectively) (Table 23).

It was evident that the P x G interaction had a significant effect on the corolla tube length of the flower. In the month of January, P_1 x G_2 (pruning during the last week of September along with cycocel 1500 ppm) (11.59 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 100 ppm) (11.73 mm), P_1 x G_9 (pruning during last week of September without growth regulator application (11.81 mm), P_2 x G_1 (pruning during the last week of October along with cycocel 1000 ppm) (11.79 mm), P_3 x G_2 (pruning during the last week of November along with cycocel 1500 ppm) (11.72 mm) were found to be on par. In the month of February P_1 x G_8 (pruning during the last week of September along with GA_3 150 ppm) (11.76 mm) and P_3 x G_2 (pruning during the last week of November along with cycocel 1500 ppm) (11.81 mm) were found to be significantly superior. During march P_1 x G_7 (pruning during the last week of September along with GA_3 100 ppm) (11.93 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 150 ppm)(11.94 mm), P_2 x G_1 (pruning during the last week of October along with cycocel 1000 ppm) (11.7 mm), P_3 x G_1 (pruning during the last week of November along with cycocel 1000 ppm) (11.61 mm) and P_3 x G_6 (pruning during the last week of November along with mepiquat chloride 300 ppm) (11.47 mm) were found to be on par. In April P_1 x G_6 (pruning during the last week of September along with mepiquat chloride 300 ppm) (11.7 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 150 ppm) (11.85 mm), P_2 x G_5 (pruning during the last week of October along with mepiquat chloride 150 ppm) (11.61 mm) and P_3 x G_5 (pruning during the last week of November along with mepiquat chloride 300 ppm) (11.49 mm) were on par (Table 24) and recorded highest corolla tube length.

4.3.9. Corolla tube girth (mm)

No significant influence of pruning time, application of growth regulators and P x G interaction could be observed with respect to corolla tube girth during the entire period of observation (Table 25 and 26).

Table 25. Effect of growth regulators on corolla tube girth (mm) of *Jasminum sambac*

Treatments		Jan 21	Feb 21	Mar 21	Apr 21
TIME OF PRUNING	P_1	2.53	2.33	2.52	2.52
	P_2	2.53	2.52	2.53	2.52
	P_3	2.54	2.54	2.54	2.56
CD (0.05)		**NS**	**NS**	**NS**	**NS**
GROWTH REGULATORS	G_1	2.52	2.55	2.55	2.54
	G_2	2.54	2.46	2.54	2.57
	G_3	2.54	2.47	2.53	2.54
	G_4	2.55	2.48	2.49	2.49
	G_5	2.52	2.44	2.54	2.56
	G_6	2.56	2.58	2.56	2.57
	G_7	2.50	2.46	2.54	2.53
	G_8	2.41	2.41	2.41	2.46
	G_9	2.52	2.40	2.54	2.53
CD (0.05)		**NS**	**NS**	**NS**	**NS**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 26. Effect of P x G on corolla tube girth (mm) of *Jasminum sambac*

Treatments	Jan 21	Feb 21	Mar 21	Apr 21
P_1 x G_1	2.62	2.62	2.58	2.54
P_1 x G_2	2.56	2.45	2.53	2.56
P_1 x G_3	2.50	2.59	2.54	2.58
P_1 x G_4	2.51	2.53	2.43	2.45
P_1 x G_5	2.46	2.55	2.65	2.60
P_1 x G_6	2.63	2.58	2.55	2.46
P_1 x G_7	2.49	2.51	2.52	2.50
P_1 x G_8	2.53	2.51	2.49	2.43
P_1 x G_9	2.50	2.56	2.45	2.50
P_2 x G_1	2.51	2.42	2.51	2.58
P_2 x G_2	2.61	2.29	2.56	2.65
P_2 x G_3	2.55	2.32	2.54	2.53
P_2 x G_4	2.62	2.42	2.62	2.52
P_2 x G_5	2.55	2.35	2.52	2.62
P_2 x G_6	2.47	2.31	2.46	2.62
P_2 x G_7	2.51	2.33	2.54	2.58
P_2 x G_8	2.48	2.24	2.53	2.42
P_2 x G_9	2.51	2.18	2.58	2.14
P_3 x G_1	2.62	2.62	2.58	2.49
P_3 x G_2	2.45	2.46	2.55	2.52
P_3 x G_3	2.59	2.58	2.50	2.52
P_3 x G_4	2.53	2.53	2.42	2.51
P_3 x G_5	2.55	2.55	2.52	2.53
P_3 x G_6	2.58	2.58	2.62	2.55
P_3 x G_7	2.51	2.51	2.55	2.55
P_3 x G_8	2.51	2.51	2.52	2.52
P_3 x G_9	2.56	2.56	2.61	2.55
CD (0.05)	**NS**	**NS**	**NS**	**NS**

4.3.10. Flower yield per plant during off-season and peak season

a. Flower yield per plant (Off season)

The data revealed that there was a significant difference in flower yield per plant during off-season (November to February) due to pruning time alone (Table 27). Plants pruned during the last week of September (P_1) (328.01 g) produced more flower yield during the off-season which was followed by P_3 (222.76 g). P_2 (pruning during the last week of October) (203.51 g) gave less yield during the entire period of observation (Table 27).

The influence of growth regulators G_1 (cycocel at 1000 ppm) (335.42 g), G_3 (paclobutrazol at 200 ppm) (320.43 g) and G_7 (GA_3 at 100 ppm) (292.07 g) were on par in terms of flower yield during the off-season.

Interaction of P x G was also found to have a significant effect with respect to flower yield during the off-season. P_1 x G_1 (pruning during the last week of September along with cycocel at 1000 ppm) gave a higher yield (572.57 g) when compared with other treatment combinations. The lowest yield was noticed in P_2 x G_9 (pruning during the last week of October with no treatment) (60.19 g) (Table 28).

b. Flower yield per plant (Peak season)

There was a significant difference among the different pruning times with regard to flower yield per plant during peak season (Table 27). Pruning during the last week of November (P_3) was found to have superior results (116.13 g) in terms of flower yield per plant during peak season followed by pruning during the last week of September (P_1) (73.77 g). The lowest flower yield was observed in pruning during the last week of October (P_2) (57.68 g).

It was found that G_1 (cycocel 1000 ppm) (108. 85 g), G_3 (paclobutrazol 200 ppm) (98.42 g) and G_7 (GA_3 100 ppm) (98.49 g) were on par when treated with different growth regulators followed by G_5 (mepiquat chloride 150 ppm) (91.91 g) and G_4 (paclobutrazol at 300 ppm) (91.91 g). The lowest yield was noticed in G_9 (Control) (35.46 g) (Table 27).

Table 27. Effect of time of pruning and growth regulators on flower yield (g) during offseason and peak season of *Jasminum sambac*

Treatments		Offseason	Peak season
TIME OF PRUNING	P_1	328.01	73.77
	P_2	203.51	57.68
	P_3	222.76	116.14
CD		**30.70**	**6.08**
GROWTH REGULATORS	G_1	335.43	108.85
	G_2	241.49	68.20
	G_3	320.43	98.42
	G_4	280.50	87.37
	G_5	267.62	91.91
	G_6	267.98	74.83
	G_7	292.07	98.96
	G_8	142.75	78.76
	G_9	114.56	35.46
CD (0.05)		**53.17**	**10.53**

P_1 - Pruning during last week of September

P_2- Pruning during last week of October

P_3- Pruning during last week of November

G_1- Cycocel @ 1000 ppm
G_2- Cycocel @ 1500 ppm
G_3- Paclobutrazol @ 200 ppm
G_4- Paclobutrazol @ 300 ppm
G_5- Mepiquat chloride @ 150 ppm
G_6 - Mepiquat chloride @ 300 ppm
G_7- GA_3 @ 100 ppm
G_8- GA_3 @ 150 ppm
G_9- Control

Table 28. Effect of P x G on flower yield (g) during offseason and peak season of *Jasminum sambac*

Treatments	Offseason	Peak season
P_1 x G_1	572.57	117.14
P_1 x G_2	298.99	71.12
P_1 x G_3	425.25	104.37
P_1 x G_4	331.25	70.66
P_1 x G_5	274.48	79.71
P_1 x G_6	370.14	61.95
P_1 x G_7	398.02	67.39
P_1 x G_8	92.88	35.68
P_1 x G_9	188.46	55.95
P_2 x G_1	238.55	93.99
P_2 x G_2	235.13	58.51
P_2 x G_3	315.55	75.82
P_2 x G_4	265.44	62.33
P_2 x G_5	222.73	66.66
P_2 x G_6	151.90	39.26
P_2 x G_7	210.72	69.33
P_2 x G_8	131.32	38.05
P_2 x G_9	60.20	15.13
P_3 x G_1	195.16	115.41
P_3 x G_2	190.36	74.97
P_3 x G_3	220.49	115.05
P_3 x G_4	244.79	129.13
P_3 x G_5	305.64	129.36
P_3 x G_6	281.90	123.29
P_3 x G_7	267.45	160.17
P_3 x G_8	204.04	162.54
P_3 x G_9	95.01	35.29
CD (0.05)	**92.09**	**18.23**

Interaction of P x G was found to have a significant influence on flower yield per plant during peak season. P_3 x G_8 (pruning during the last week of November along with GA_3 at 100 ppm) (162.54 g) and P_3 x G_7 (pruning during the last week of November along with GA_3 at 150 ppm) (160.7 g) were found to be on par during peak season which followed by P_3 x G_5 (pruning during last week of November along with application of mepiquat chloride at 150 ppm) (129.36 g), P_3 x G_4 (pruning during last week of November along with application of mepiquat chloride at 100 ppm) (129.13 g) and P_3 x G_6 (pruning during last week of November along with application of mepiquat chloride at 300 ppm) (123.29 g). The lowest yield was observed in P_3 x G_9 (pruning during the last week of November with no treatment) (35. 29 g) (Table 28).

4.4. INCIDENCE OF PESTS AND DISEASES

4.4.1. Incidence of pests

a. Bud worm *(Hendecasis duplifascialis)*

Incidence of bud worm was noticed from the months January 21 to March 21. Tiny caterpillars make holes in the flower bud, feed on the inner content of the bud. It makes a circular hole on the corolla tube, emerged and tunnel to move into other buds of the same shoot. Adjacent flower buds are webbed together by means of silken thread.

Management practices like raking of soil for exposing pupae to sun, setting up sticky trap and treating with Chlorpyrifos 20 EC at the rate of 2 ml per litre were adopted to control, the infestation.

b. Jasmine midge *(Contarinia maculipennis)*

Blossom midge caused damage to the buds during the months from March 21 to June 21. The midge maggots entered into the buds at the base of the corollas resulting in swelling and shrivelling at the base of the buds. These maggots fed inside the unopened flower buds which result in deformed, pink discoloured buds and blossoms. When severely infested it was noticed that buds dried prematurely leading to bud drop or blossom drop in the field.

Bud worm *(Hendecasis duplifascialus)*

Jasmine midge (*Contarinia maculipenis*)

Bacterial wilt

Plate 6. Pest and disease incidence

Collection and destruction of fallen and discoloured flower buds, raking the soil to kill pupae in the ground, setting of sticky traps and spraying of Fipronil 2ml per litre were the management practices adopted to control the infestation.

4.4.2. Incidence of diseases

a. Bacterial wilt

The disease occured in patches and the roots were found to have black colouration on the entire plant. The entire complete plant showed wilting leading to death of the plant.

Uprooting of infected plants and drenching the soil up with Saaf at 2ml per litre helped to control the further spread of the disease.

Discussion

5. DISCUSSION

Jasmine is an important commercial loose flower crop grown in India which is mainly used in South Indian states. Being a promising crop, it is used as a raw material of perfumes and in the cosmetic industry. Jasmine is a seasonal crop that gives higher yield during the period March to June in South Indian conditions and the heavy production during this season leads to market surplus. On the other hand, there is a shortage of flowers during the months of November to February (off-season) which coincides with the major religious festivals and ceremonies. In order to meet the huge market demand during the off-season, it is essential to combine different agro techniques to produce flowers during the off-season. Pruning is a cultural operation carried out in jasmine for inducing productive shoots and growth regulators are applied to regulate the flowering.

The present study is carried out to understand the combined effect of both these practices for the induction of off-season flowering in jasmine. The results generated from the studies on the effect of time of pruning and growth regulators on growth, flowering, yield and physiological characters of *Jasminum sambac* in order to induce off-season flowering are discussed in this chapter.

5.1. Effect of treatments on growth parameters

Pruning is one of the important cultural operations in the cultivation of Jasmine. Pruning encourages growth of new healthy shoots which bear more flowers than old shoots by diverting sap flow towards flowering shoots. In this study, three pruning times were tried *viz.* P_1 (pruning during the last week of September), P_2 (pruning during the last week of October), P_3 (pruning during the last week of November). Irrespective of the time of pruning an improvement was noticed in every growth parameter during the period of observation. Regarding plant height, an increasing trend was observed throughout the months of observation from January to June (Figure 1). Plants pruned during last week of September (P_1) had the greatest plant height (101.17 cm) during the major part of the observation period. It is evident that the time of pruning had a significant effect on the plant height. According to Pal and Krishnamurthi (1967) and

Rai (1984), *Jasminum* spp. requires a maximum temperature of 30°C for favourable growth and floral induction and the average temperature during the month of September (32.4°C) which would have promoted growth and flowering in jasmine. Similar results were also observed by Kumar *et al.* (2021) in *Jasminum multiflorum*. Pruning during last week of November (P_2) resulted in the minimum plant height at flowering. This might be due to the effect of weather conditions with low heat units leading to a reduction in rate of photosynthesis and restricted cell enlargement. This finding is in consonance with the observation of Jennoah (2012), Chaitanya (2013) and Kumaresan *et al.* (2017) in *Jasminum sambac,* Khanchana (2019) in *Jasminum auriculatum* and Kumar *et al*. (2021) in *Jasminum multiflorum*.

Pruning during last week of September (P_1) and pruning during last week of October (P_2) had more significant influence in terms of plant spread (Figure 3). Pruning reduces apical dominance and enhances lateral growth of the plant (Hugar and Nalawadi, 1993). Pruning treatments significantly increased the plant spread which might be due to suppression of apical dominance that produced a greater number of lateral branches, resulting in increased plant spread in both directions as observed by Ratikanth (2005) Lokhande *et al.* (2015), Kumaresan *et al*. (2017) and Kalaimani *et al.* (2017) in *Jasminum sambac*. Similar results were also obtained by Kumar (2021) in *Jasminum multiflorum,* Khanchana (2019) in *Jasminum auriculatum* and Santhoshini (2014) in Rose.

Pruning had no significant effect in relation to the number of secondary and primary branches. These findings were in contradiction with the findings of Muthuswami *et al*. (1973), Krishnamoorthy (2014), Kalaimani *et al.* (2018) in *Jasminum sambac*.

Plant height was significantly greater in treatments with growth regulators compared to control. GA_3 treated plants were the tallest (96.72 cm) among all treatments (Figure 2). This may be due to the enhanced cell division, cell enlargement and promotion of protein synthesis by exogenous application of GA_3 which might have ultimately resulted in enhanced vegetative growth as reported by Sobhana (2014), Rao and Sushma (2016) and Dhanasekharan *et al.* (2018) in *Jasminum sambac* and Sekhar

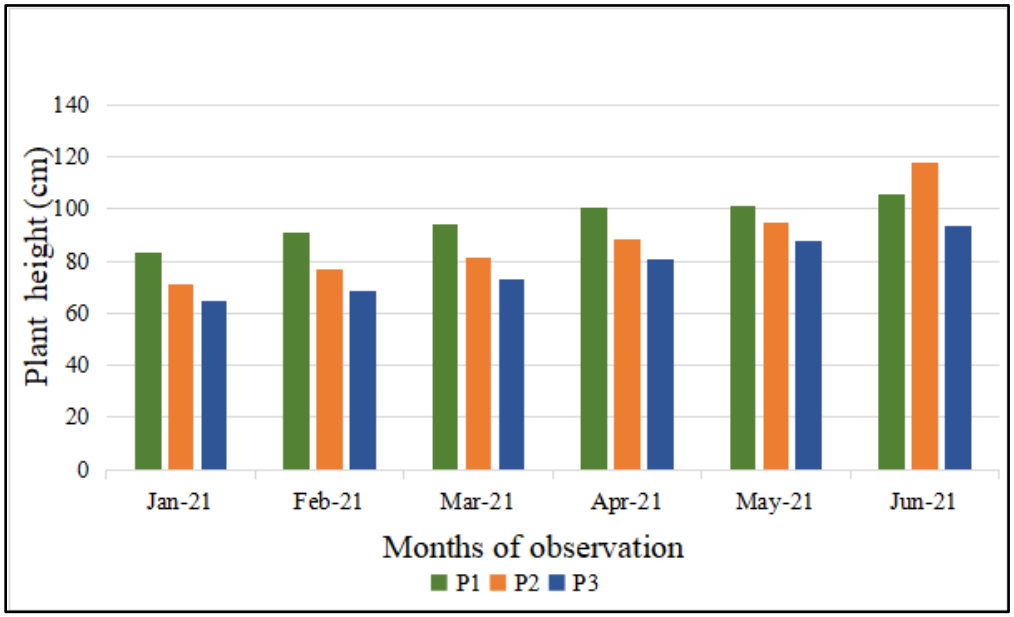


Figure 1. Effect of time of pruning on plant height

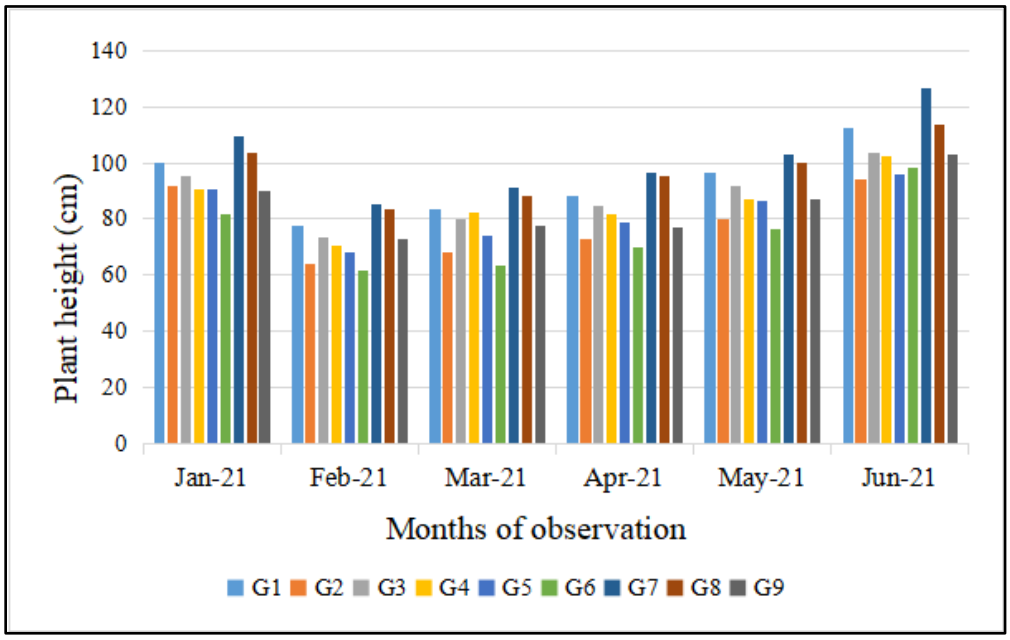


Figure 2. Effect of growth regulators on plant height

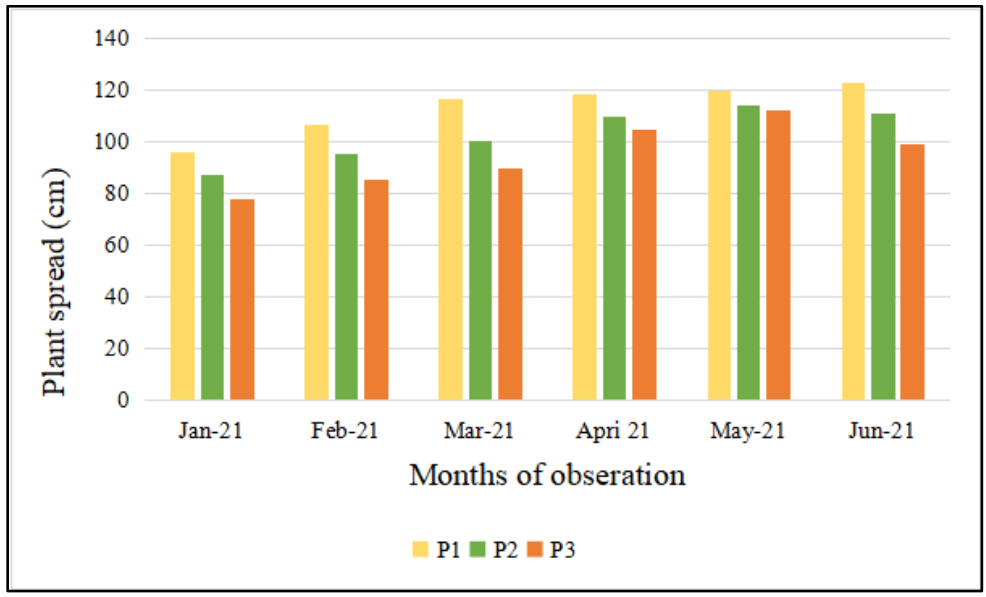


Figure 3. Effect of time of pruning on plant spread

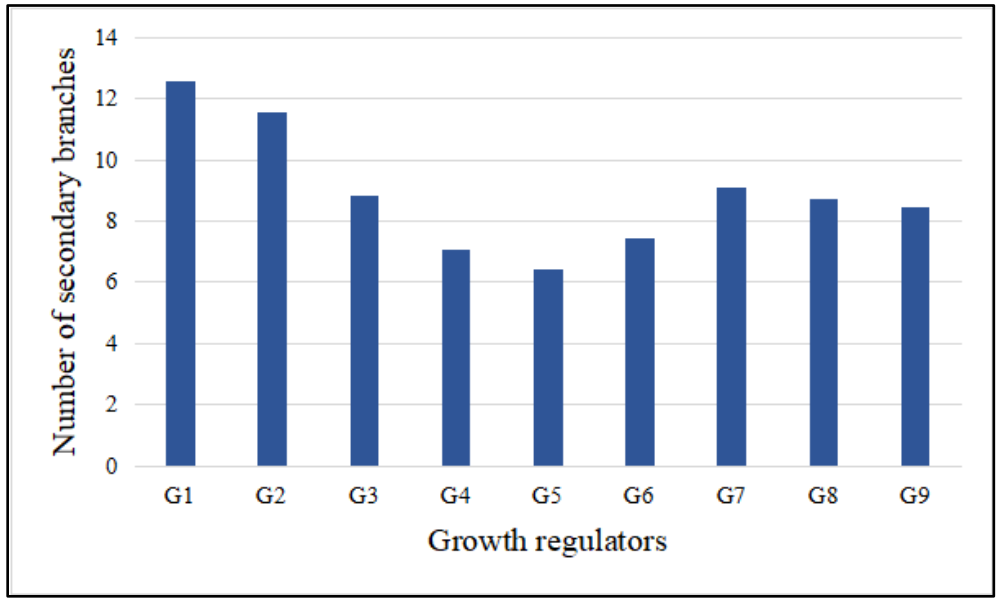


Figure 4. Effect of growth regulators on plant spread

et al. (2020) had observed similar results in *Jasminum nitidum*. Gibberellin differentially regulates auxin induction. The interaction between auxin and gibberellin is a prerequisite for stem elongation (Ockerse and Galston, 1967). Increased plant height in treatments with paclobutrazol and cycocel may be due to the increase in number of internodes in lateral branches in jasmine as stated by Dhanasekharan (2019). Similar results were also reported by Girish (2012) in daisy, Jeevan *et al*. (2020) in African marigold and Mirheidari (2021) in *Hibiscus sabdariffa*.

Number of secondary branches showed a significant difference when treated with cycocel (Figure 4). Application of cycocel might have retarded the cell division in apical bud resulting reduced growth of main axis. This, in turn, caused flow of metabolites to lateral parts of plant, resulting in production of more secondary branches (Maharana and Pani, 1982). The results are in agreement with the findings of Sumangala *et al*. (2003) in *Jasminum sambac* and Sekhar *et al.* (2020) in *Jasminum nitidum*. Similar results were also noticed by Jagdale *et al*. (2017) in annual chrysanthemum when treated with cycocel and paclobutrazol.

5.2.1. Effect of treatments on physiological parameters

A significant difference in specific leaf area was noticed with growth regulators. The treatment G_9 (untreated plants), G_7 (GA_3 100 ppm), G_5 (mepiquat chloride 150 ppm), G_8 (GA_3 100 ppm), G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm) were found to be on par in terms of this parameter (Figure 5). Increase in specific leaf area when treated with GA_3 may be because they promote cell enlargement and cell division that in turn enhance specific leaf area. Zulfiqar *et al.* (2019) noticed a similar increase in leaf area when treated with GA_3 at different levels of treatment in *Gazania regens*. Starman *et al.* (1989) reported that cycocel significantly reduced leaf area of *Helianthus* cultivars. The reduction in specific leaf area under cycocel treatment may be due to reduction in cell size due to action of the growth retardants. A decrease in leaf area is normally observed in treatments with paclobutrazol and mepiquat chloride but here the increase in their specific leaf area might be due to their corresponding increase in leaf dry mass. According to Suradinata *et al.* (2013) application of paclobutrazol at

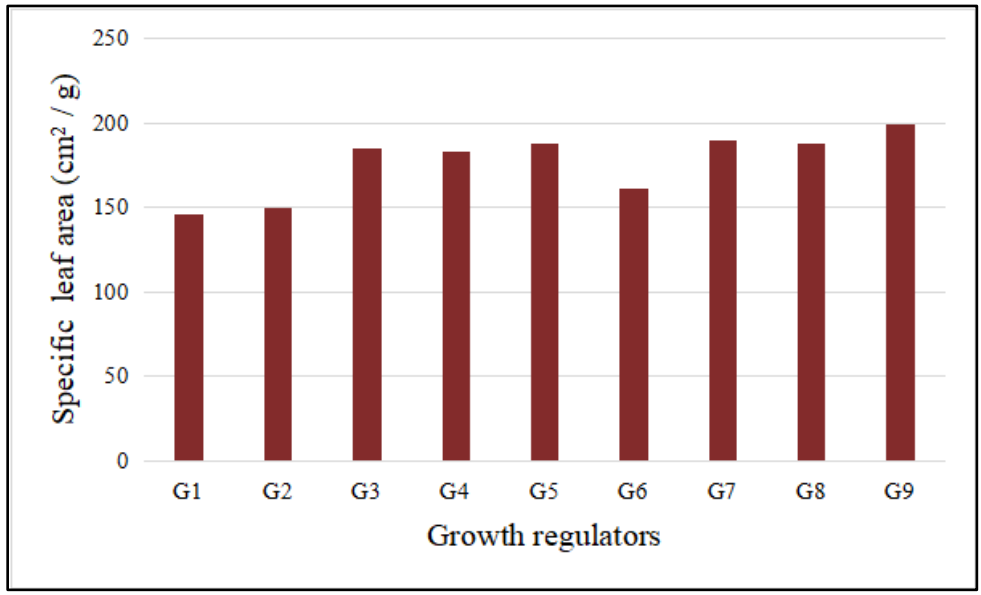


Figure 5. Effect of growth regulators on Specific Leaf Area

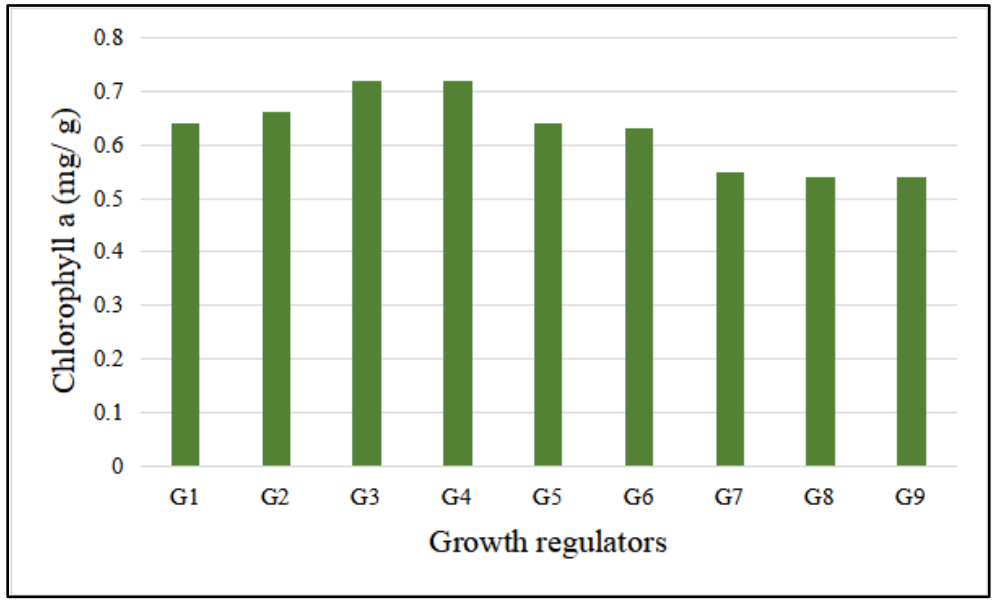


Figure 6. Effect of growth regulators on Chlorophyll a content

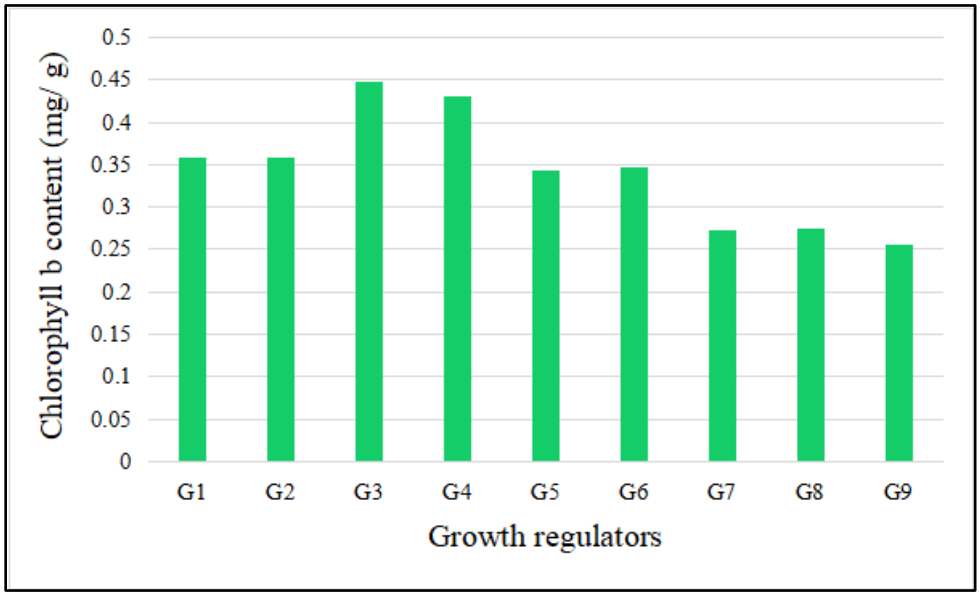


Figure 7. Effect of growth regulators on Chlorophyll b content

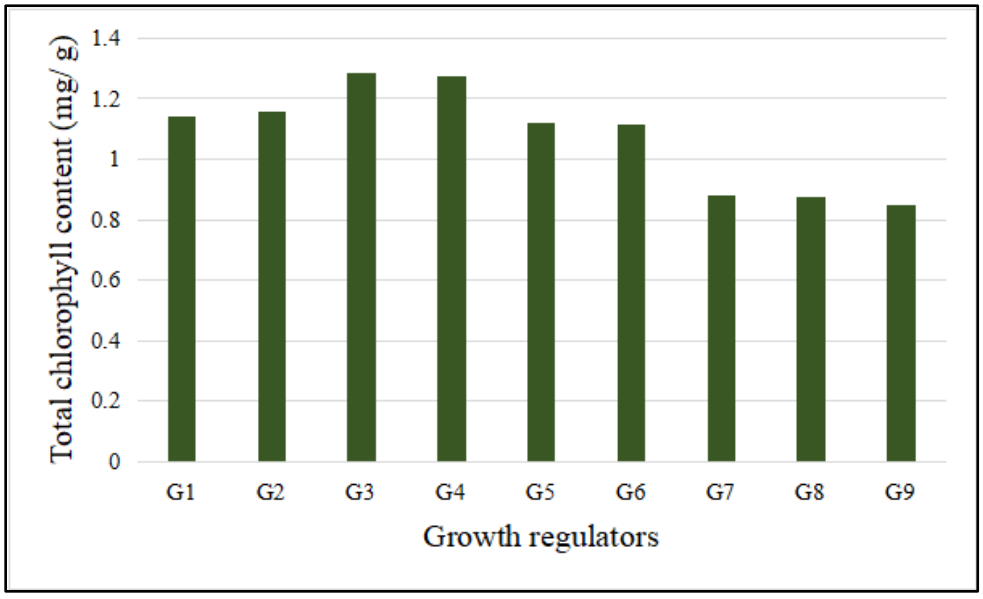


Figure 8. Effect of time Growth regulators on Total Chlorophyll content

300 ppm had the smallest leaf area and higher specific leaf area when compared to control in *Begonia rex-cultorum.*

The influence of the growth regulators on chlorophyll a, chlorophyll b and total chlorophyll content of leaves was significant. The treatments G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm) were found to be on par for chlorophyll a (Figure 6), chlorophyll b (Figure 7) and total chlorophyll content (Figure 8) of leaves. Hamza *et al*. (1983) recorded that treating plants of *Pelargonium zonale* with paclobutrazol significantly increased the total chlorophyll content when compared with the control treatment. Ahmade (2019) also noted that increased concentrations of paclobutrazol resulted in a more direct increase in chlorophyll intensity in chrysanthemum and the treated plants exhibited greener leaves, in comparison to the control. Paclobutrazol had a similar effect on chlorophyll content of leaves in *Arabidopsis thaliana* (Ribeiro *et al*., 2012), in ornamental peppers (Franca *et al*., 2018) and in potato (Tsegaw *et al*., 2005). Berova and Zlatev (2000) found a 21–23% increase in chlorophyll concentration in tomato (*Lycopersicon esculentum* Mill, 'Precador') plants treated with foliar and soil-based applications of paclobutrazol. The reason for the increase in chlorophyll concentration by paclobutrazol has not been fully characterized; however, possible explanations have been proposed. One possible explanation is the relatively high density of chloroplasts per leaf area or maybe due to application of paclobutrazol does not affect cell division, just cell expansion; therefore, there are more cells (and possibly chloroplasts) concentrated into a smaller area. Another possible explanation is an increase in chloroplast differentiation and chlorophyll biosynthesis, as well as a reduction in chlorophyll degradation caused by paclobutrazol stimulation of cytokinin biosynthesis (Kumaresan *et al*., 2017). This may be due to the inhibitor effect of growth retardants that produced smaller cells and thus resulted in more concentrated chlorophyll content inside the reduced cell volume (Thakur *et al*., 2006).

5.3.1. Effect of treatments on flowering parameters

In jasmine pruning effects flowering by utilization of energy by eliminating unwanted shoots (Muthuswami *et al*., 1973). The data related to the number of days taken for first flower bud initiation was influenced significantly by pruning time (Figure

9). Minimum number of days for emergence of first flower was recorded in plants pruned during last week of November whereas, pruning during the last week of September recorded significantly late emergence of first flower. The vegetative phase in the late pruning (November pruning) was less as compared to other treatments. The results are in close conformity with the findings of Lokhande *et al*. (2015) in *Jasminum sambac* and Gowda *et al.* (1986) in *Jasminum auriculatum.*

Pruning time had a significant influence on the number of cymes per plant in the months of February to April (Figure 12). Plants pruned during last week of November (P_3) was found to produce more number of cymes during the study period. Lowest number of cymes per plant was observed in plants pruned during last week of October (P_2) throughout the period of observation. Regarding the number of buds per plant, during the initial months of observation, time of pruning had no significance with respect to this parameter. During February, March and April, plants pruned during last week of November (P_3) had the highest number of buds per plant (Figure 15). Throughout the study, pruning during last week of October (P_2) showed the lowest number of buds per plant Increase in number of productive shoots and proper canopy architecture on leaves might have favoured efficient absorption of solar energy and ultimately resulted in higher photosynthate accumulation as well as translocation of metabolites that facilitated a higher number of cymes per plant. Similar observations of increase in number of cymes/ plant due to pruning was reported in *Jasminum sambac* by Hugar and Nalawadi (1993) and Pal (2017). Beneficial effect of pruning on number of flower buds per plant was reported in *Jasminum sambac* by Chopde *et al.* (2017) and Kumar (2021) in *Jasminum multiflorum.*

Earliness in bud initiation was noticed in plants treated with cycocel 1000 ppm followed by cycocel at 1500 ppm (11.01 days) (Figure 10). Growth regulators had a significant influence on the number of cymes per plant throughout the study period. G_1 (cycocel 1000 ppm) and G_3 (Paclobutrazol 200 ppm) were found to be on par throughout the experiment period along with G_7 (GA_3 100 ppm) during January and February.

Exogenous application of cycocel might have caused polymerisation of sugars that are utilized for vegetative growth. Due to polymerization, sugars are converted to storage carbohydrates, resulting in retardation of plant growth (Cohen, 1978). These reserved carbohydrates might have been utilized for reproductive growth. Application of cycocel also might have caused reduction in the level of endogenous gibberellin, leading to early bud initiation and flowering. In the present study, more number of secondary branches were observed under G_1 (cycocel 1000 ppm). As jasmine produces flowers on current season growth, production of more number of secondary branches might have increased number of cymes and number of flower buds in these treatments. The beneficial influence of cycocel on flower yield was recorded in *Jasminum multiflorum* by Murali and Gowda (1988). Similar results of early flowering was noticed in *J. multiflorum* (Bhattacharjee, 1994) and in *Jasminum sambac* by Gowda *et al*. (1991). With regard to number of cymes (Figure 13) and number of flower buds per plant (Figure 16), G_3 (paclobutrazol at 200 ppm) was also found to be superior and on par with (G_1) (cycocel 1000 ppm). Treating it with paclobutrazol might have caused a reduction of plant growth and an increase in carbohydrate content of leaves, resulting in production and translocation of metabolites for production of flower buds (El - Sadek, 2018). During the experiment, more leaf area as well as high chlorophyll content were observed under paclobutrazol application which might have increased the rate of photosynthesis and formation of more number of cymes as well as flower buds.

Weight of 100 flowers was significantly influenced by the application of different levels of growth regulators (Figure 18). Treatments G_7 (GA_3 100 ppm) showed significance throughout the period and was on par with G_8 (GA_3 150 ppm). The lowest weight of 100 flowers is observed in G_9 (untreated plants) throughout the months of observation. In April, G_7 (GA_3 100 ppm) (26.13 g) and G_8 (GA_3 150 ppm) (26.71 g) were on par for the weight of 100 flowers and were followed by treatment G_1 (cycocel 1000 ppm), G_2 (cycocel at 1500 ppm), G_5 (mepiquat chloride 150 ppm) and G_6 (mepiquat chloride 300 ppm). This may be due to the increased production of carbohydrates and translocation of to sink when treated with growth regulators as stated by Sasikumar *et al* (2015).

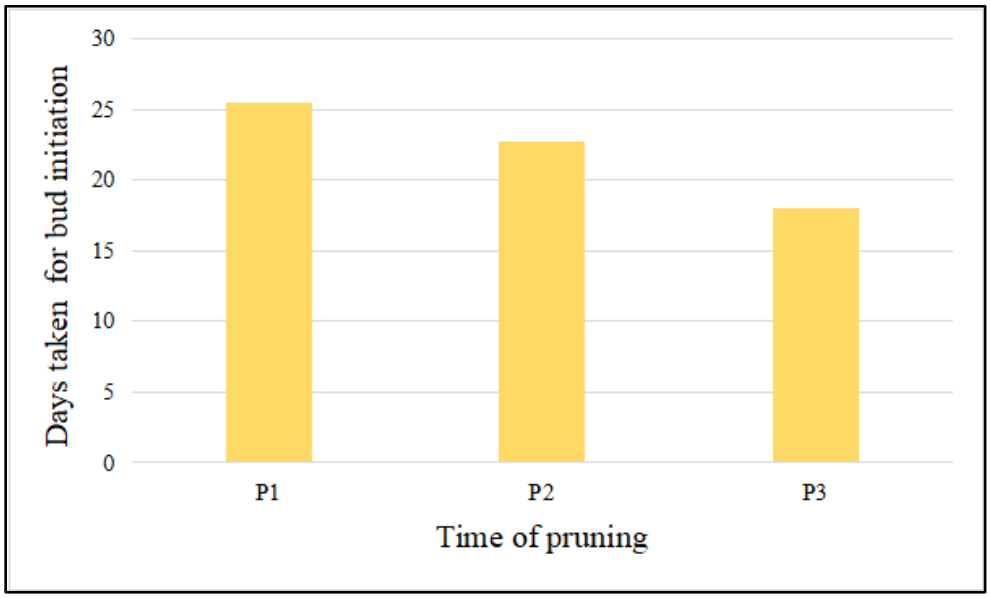


Figure 9. Effect of time of pruning on days taken for bud initiation

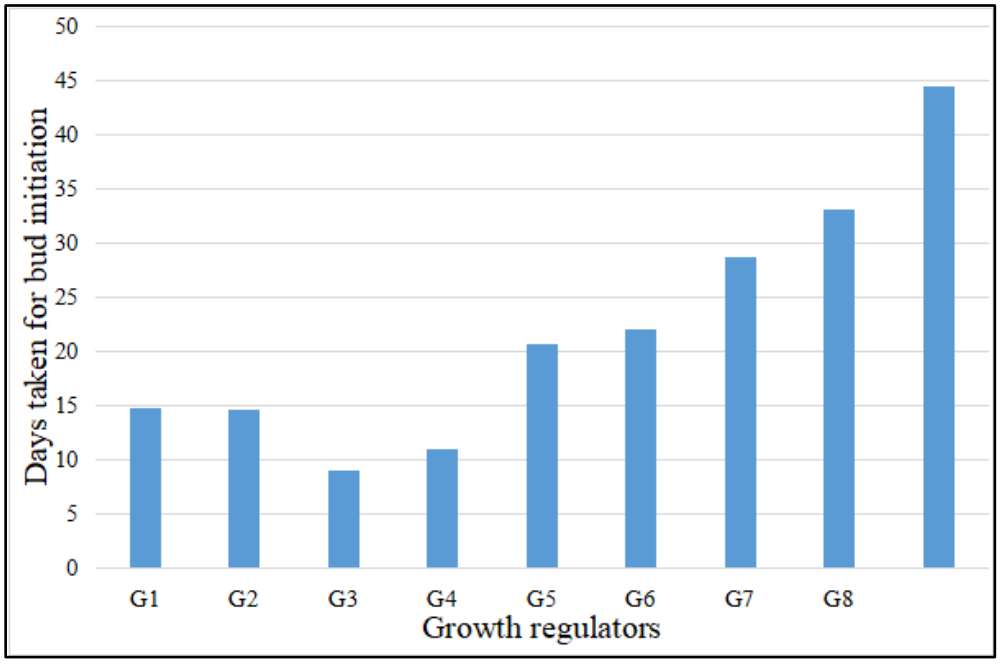


Figure 10. Effect of growth regulators on days taken for bud initiation

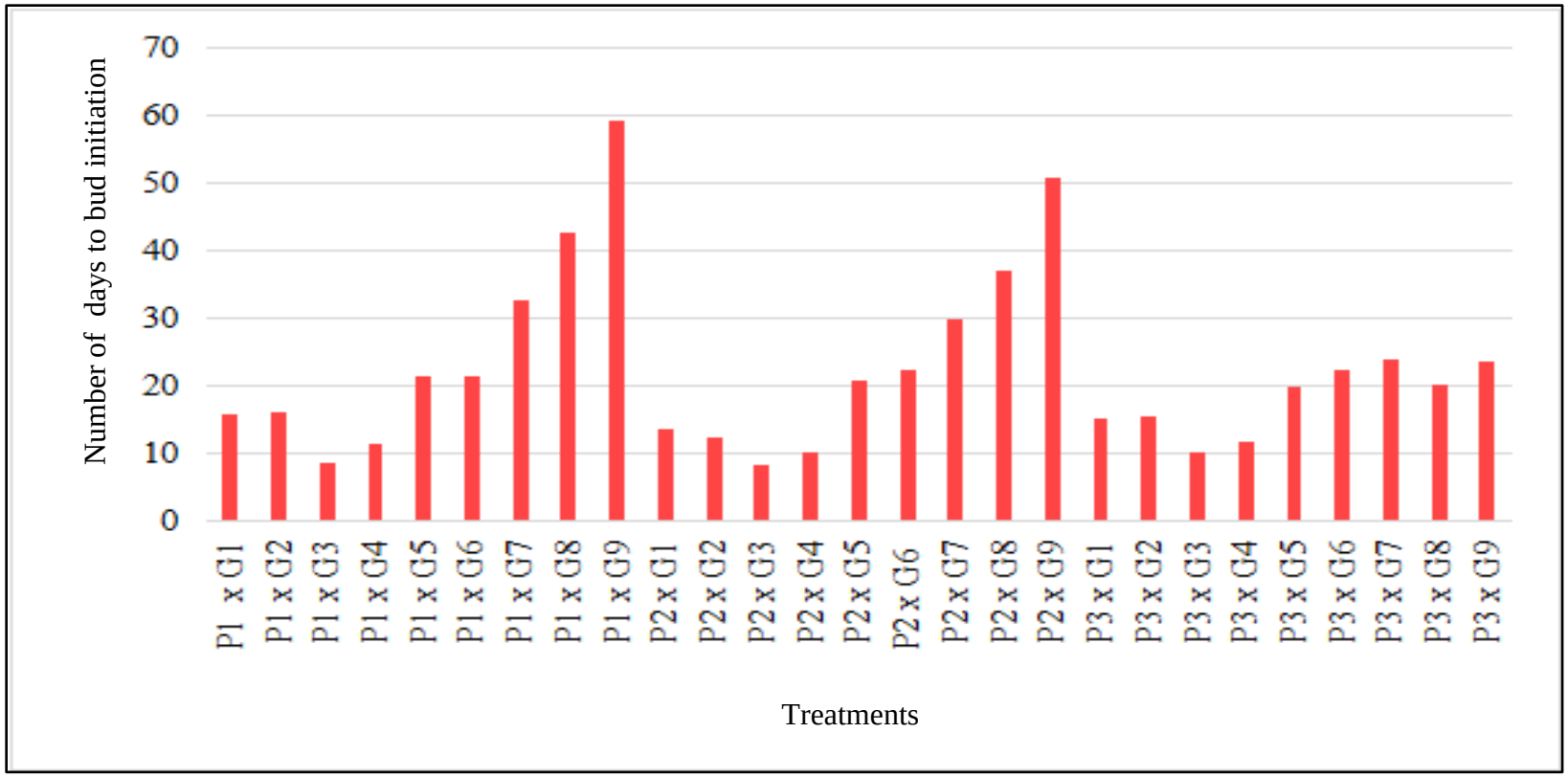


Figure 11. Effect of P x G on days to bud initiation

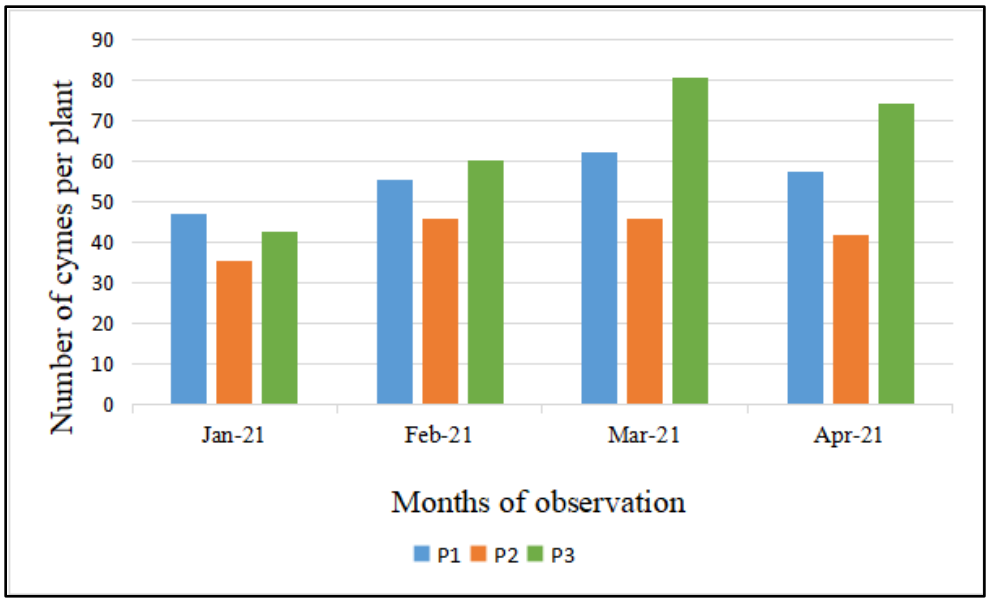


Figure 12. Effect of time of pruning on number of cymes per plant

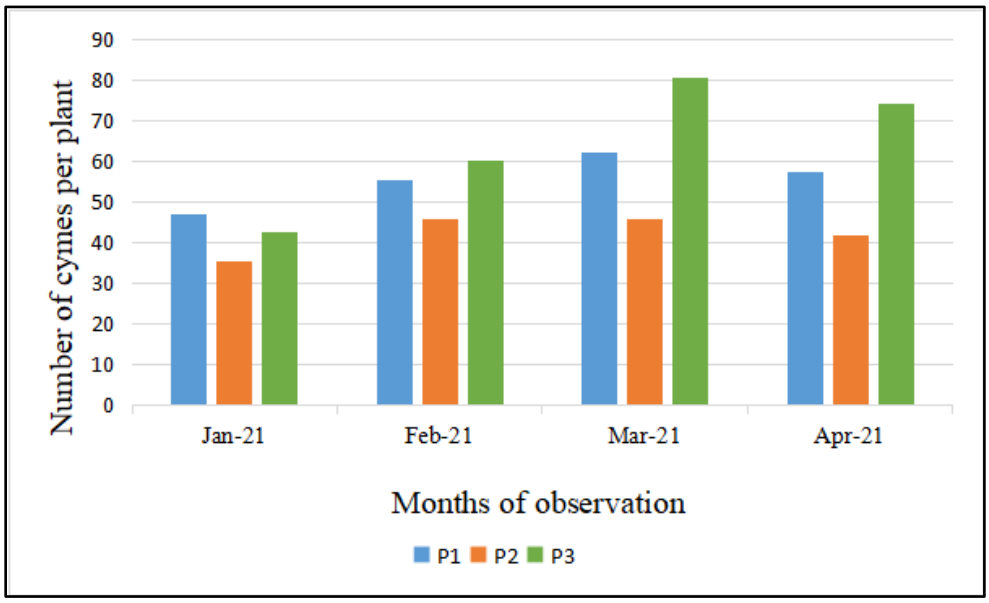


Figure 13. Effect of growth regulators on number of cymes per plant

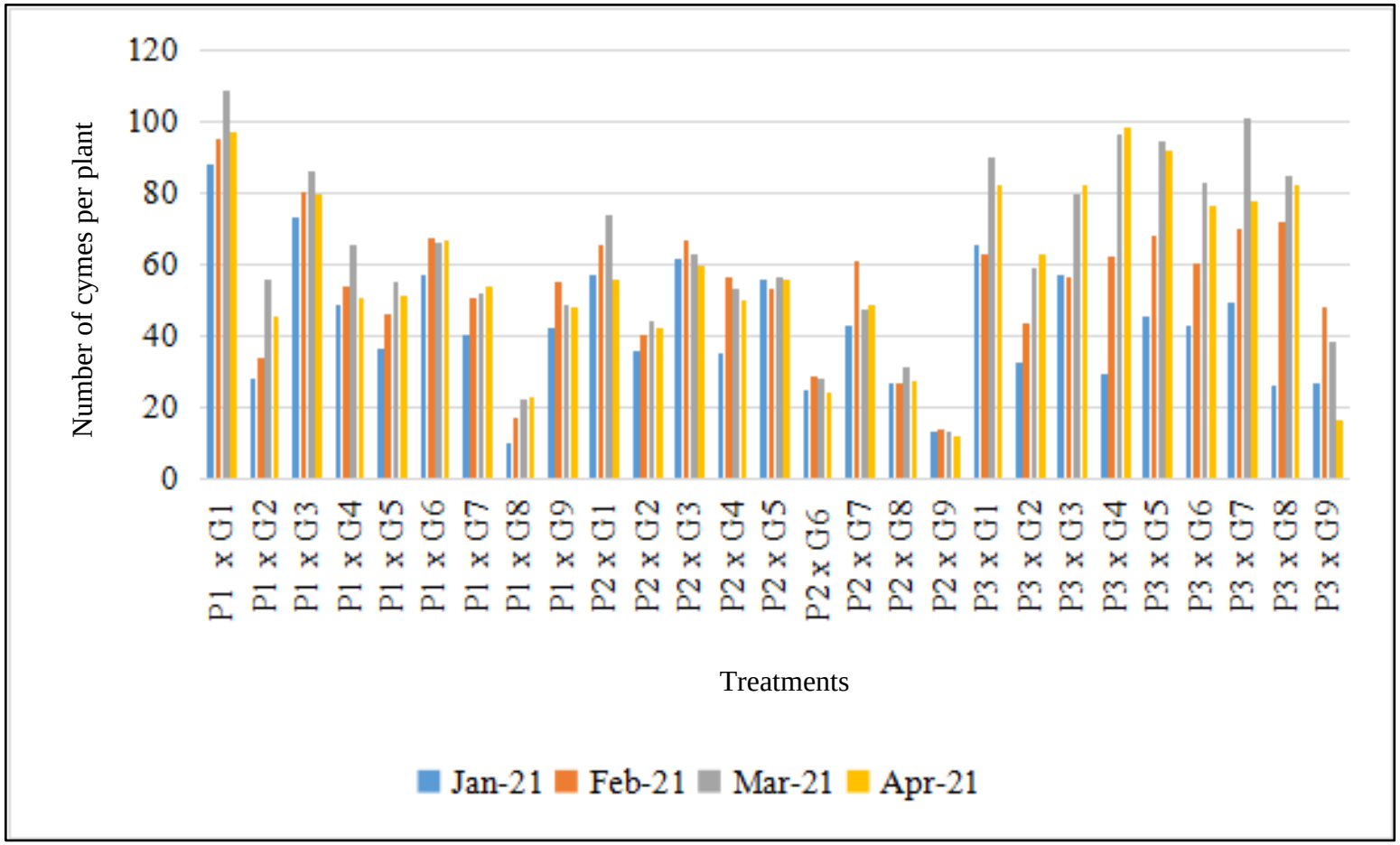


Figure 14. Effect of P x G on number of cymes per plant

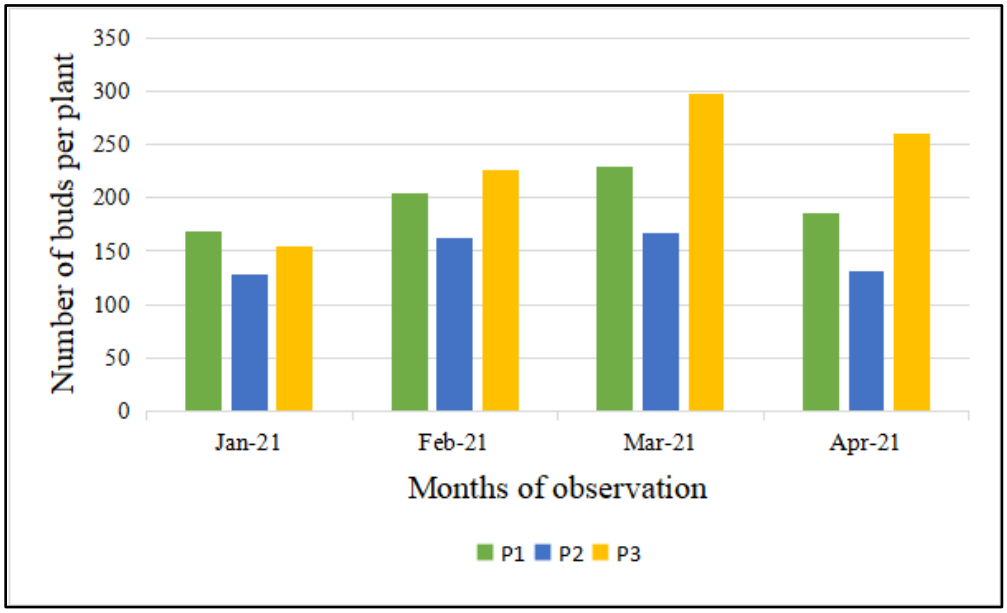


Figure 15. Effect of time of pruning on number of buds per plant

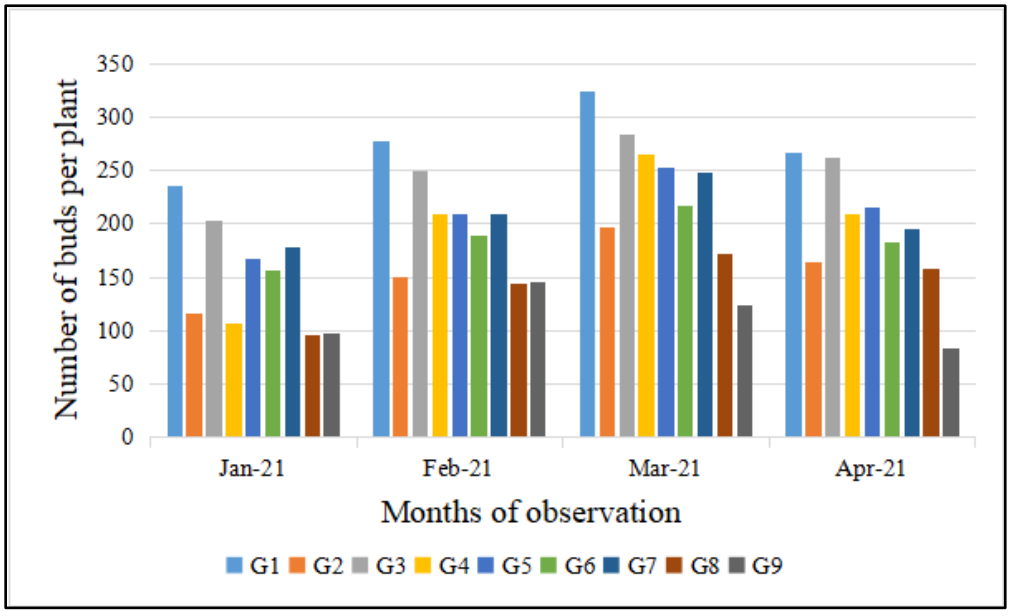


Figure 16. Effect of growth regulators on number of buds per plant

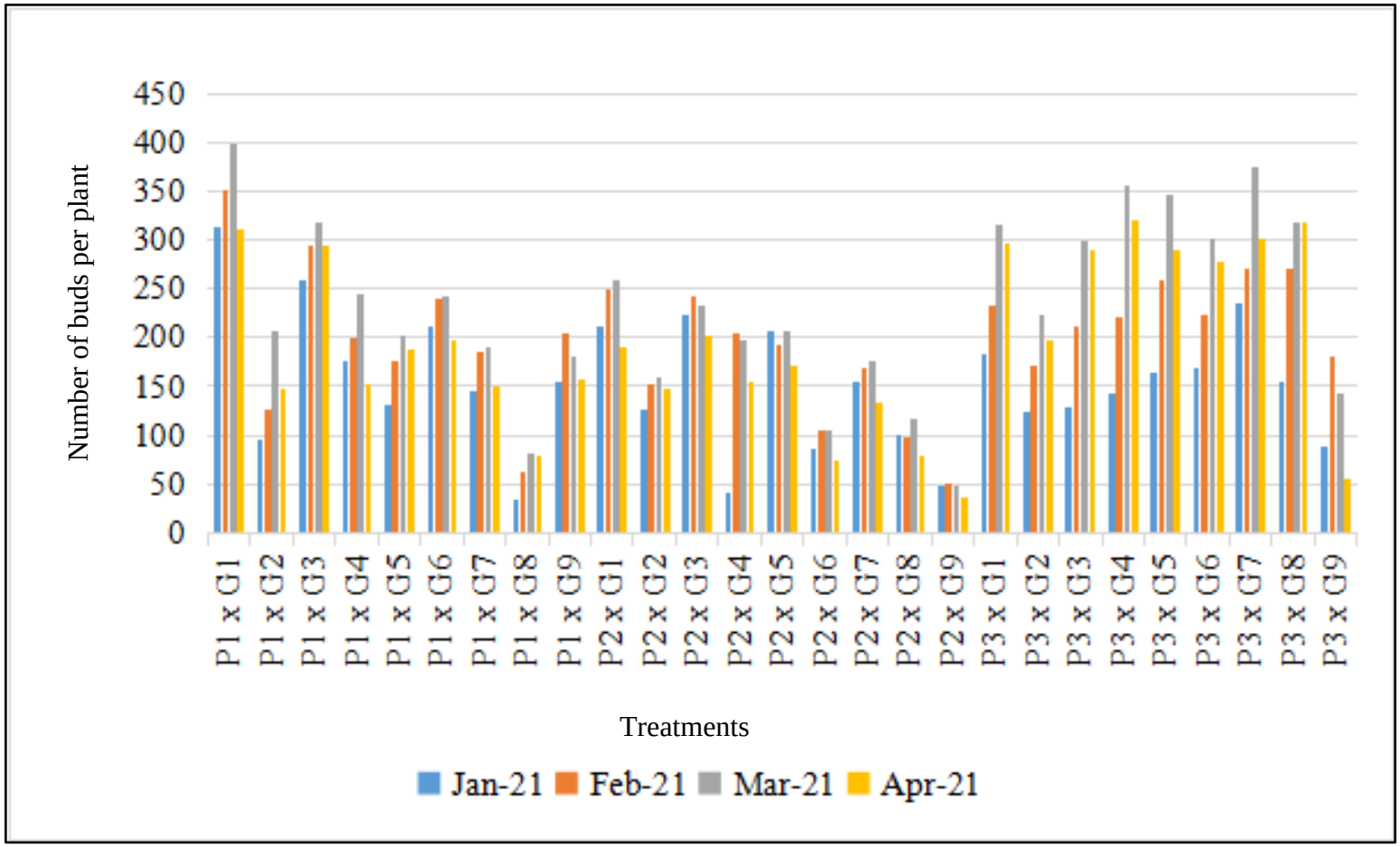


Figure 17. Effect of P x G on number of buds per plant

5.4. Effect of treatment on quality parameters

Time of pruning on length of flower bud showed a significant influence only in the month of March (Figure 19). Pruning during the last week of September (P_1) showed significantly higher value for length of flower bud (11.44 mm) which was followed by pruning during last week of November (P_2) (11.11 mm) and pruning during last week of November (P_3) (11.14 mm).

The growth regulator application had a significant effect on the length of flower bud only in the month of February (Figure 20). In the month of February except for G_9 (untreated plants) application of growth regulators showed a significant difference in terms of length of flower bud. G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm), G_3 (paclobutrazol 200 ppm) G_4 (paclobutrazol 300 ppm) G_5 (mepiquat chloride 150 ppm), G_6 (mepiquat chloride 300 ppm), G_7 (GA_3 100 ppm) and G_8 (GA_3 at 150 ppm) had more length of flower bud when compared with the untreated plants (11.26, 11.11, 11.25, 11.21, 11.16, 11.27, 11. 27 and 11.10 mm respectively). Similar observations were noticed by Chopde *et al*. (2017) in *Jasminum sambac* when treated with growth regulators.

An improvement in corolla tube length was observed under treatments consisting of cycocel (1000 ppm and 1500 ppm) throughout the growth period. However during initial months G_3 (paclobutrazol 200 ppm) and G_8 (GA_3 100 ppm) were also found to be promising with respect to this parameter (Figure 21).

It is noticed that plants treated with different growth regulators produced better quality flower buds when compared to the control plants. This might be due to the fact that increased vegetative growth caused more photosynthetic products which in turn produced better quality flowers. These results were supported by Saiyed *et al*. (2010) in gaillardia and Singh *et al.* (2018) in Chrysanthemum. Effect of application of paclobutrazol on flower quality is supported by Kumaresan *et al.* (2017) in *Jasminum sambac*. It might be due to amount of cytokinin formed by the application of paclobutrazol.

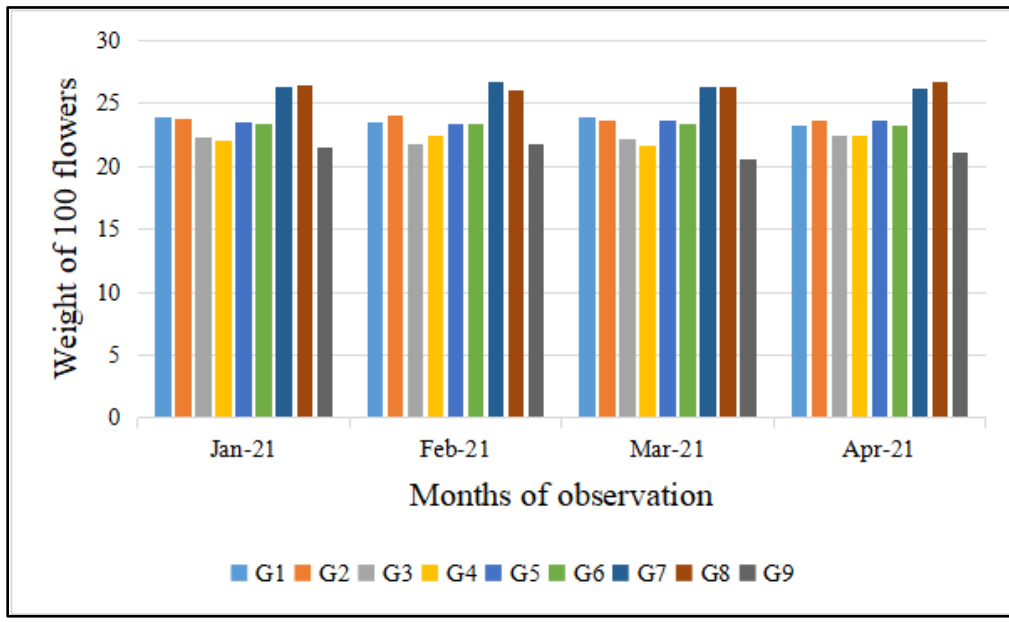


Figure 18. Effect of growth regulators on weight of 100 flowers

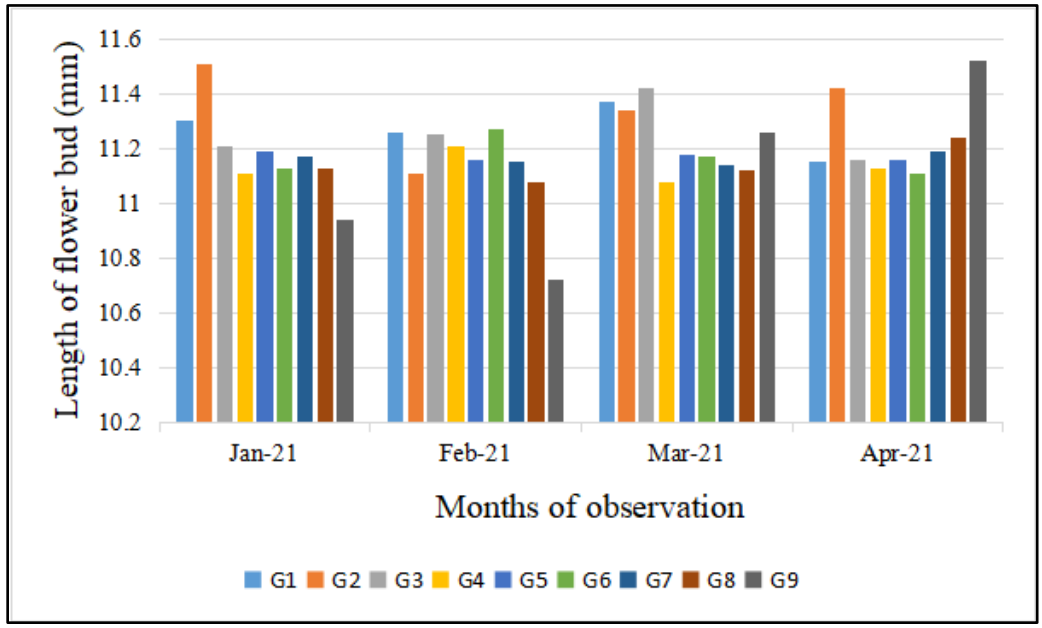


Figure 19. Effect of time of pruning on length of flower bud

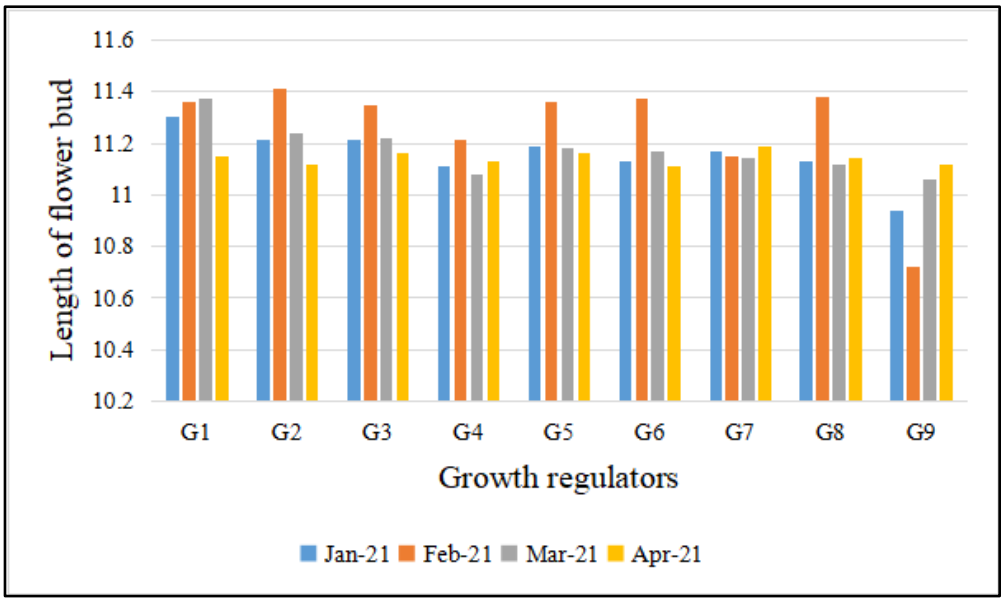


Figure 20. Effect of growth regulators on length of flower bud

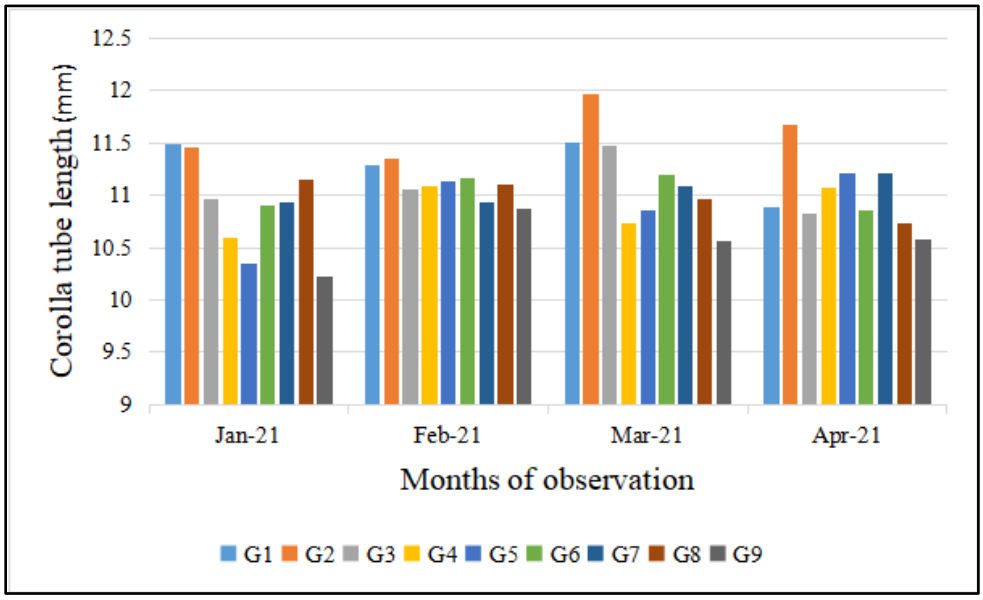


Figure 21. Effect of growth regulators on corolla tube length

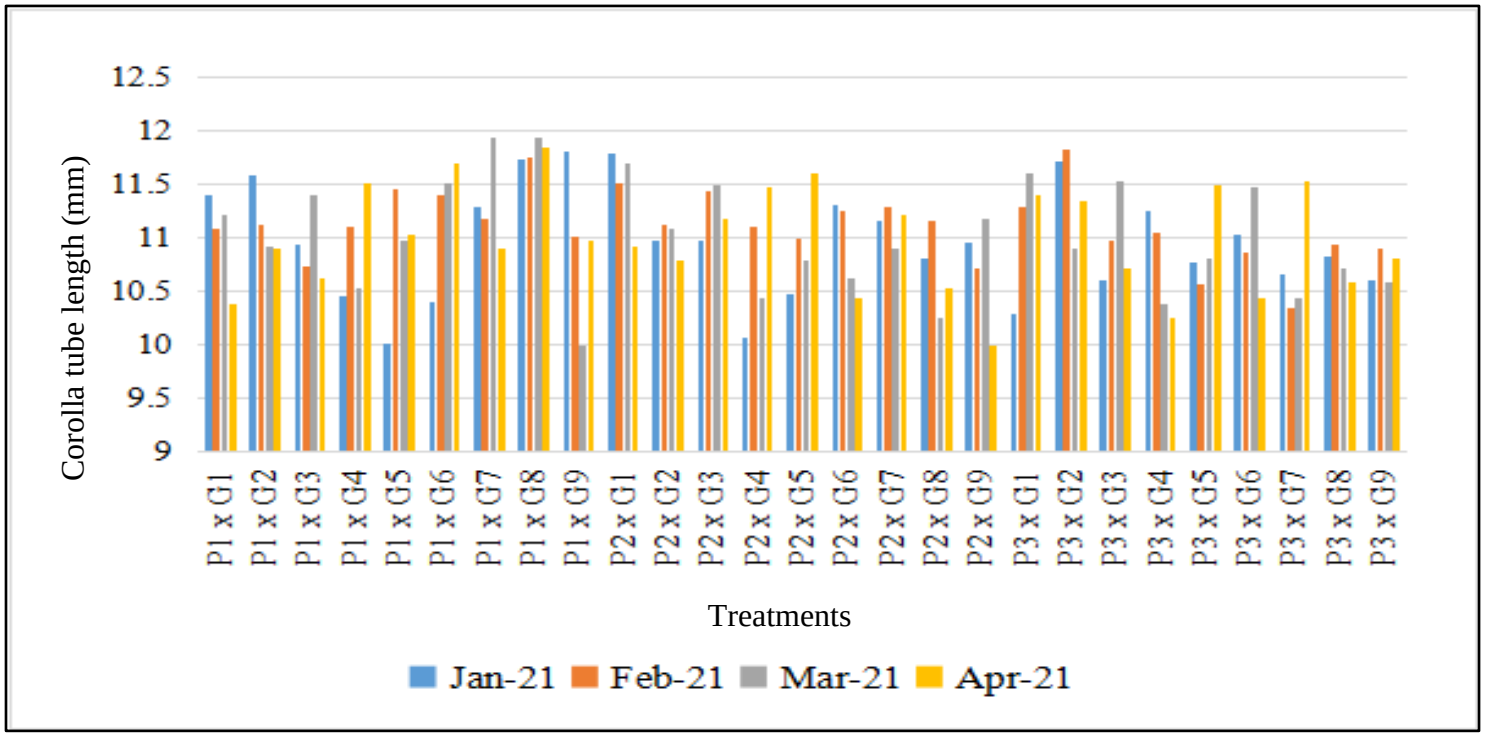


Figure 22. Effect of P x G on corolla tube length

5.5.1. Effect of treatments on yield parameters

The time of pruning had a significant influence on flower yield per plant during the months of February, March and April (Figure 19). Flower yield of plants pruned during last week of September (P_1) (42.80 g) was on par with pruning during the last week of November (P_3) (48.93 g) in the month of January. In the month of March and April, plants pruned in November (P_3) showed significantly higher flower yield (58.21 and 57.92 g respectively).

In respect of off-season flower yield, plants pruned during last week of September (P_1) gave higher yield which was followed by plants pruned during November (P_3). September pruned plants got sufficient time to put forth new growth during the off-season which might have contributed to higher off-season yield. On the other hand during peak season plants pruned during last week of November gave the best yield. This might be due to the vegetative growth in off-season which contributed to more flowering during peak season.

Flower yield is dependent on the number of flowering branches. Production of more foliage in November and September pruned plants might have resulted in increased photosynthesis and ultimately large reserve food source leading to production of more number of flowers as reported by Kumaresan *et al.* (2017). The better flower quantity resulted in September pruned plants might be due to better vegetative growth and the production of larger quantities of reserve food in comparison to the plants pruned during other months. Similar results were noticed in studies conducted by Jennoah (2012), Chaitanya (2013) and Kalaimani *et al.* (2017) in *Jasminum sambac.*

It was found that growth regulators had a significant influence on flower yield throughout the period of observation (Figure 24). It was found that G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm) and G_7 (GA_3 100 ppm) were on par with respect to flower yield. The lowest yield was noticed in G_9 (untreated plants) which was similar to the findings of Dhanasekharan (2018) in *Jasminum sambac* and Sudhagar *et al*. (2017) in *Jasminum grandiflorum.*

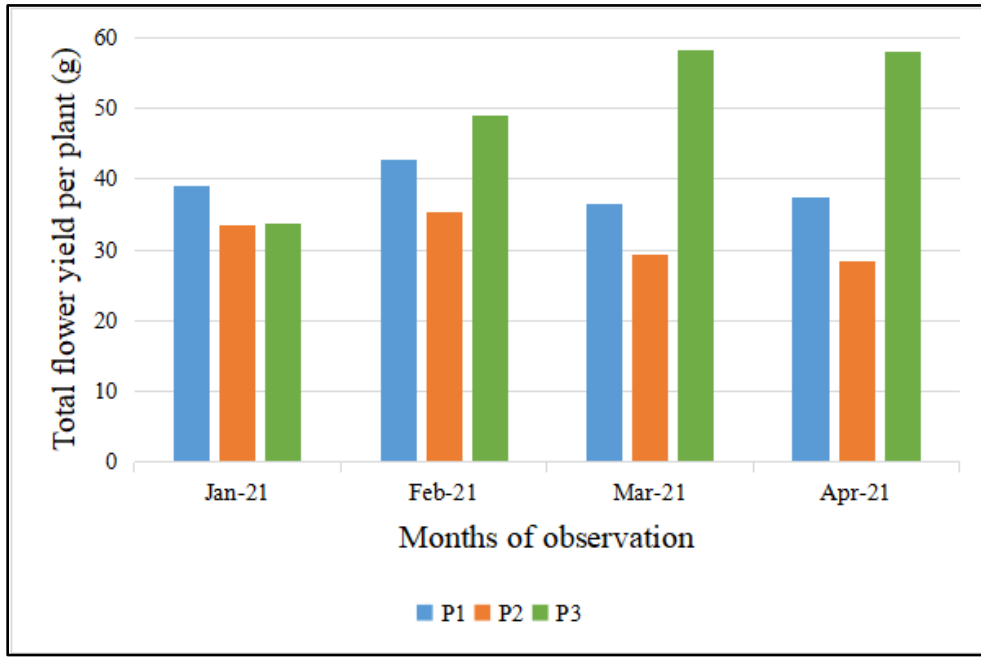


Figure 23. Effect of time of pruning on total flower yield

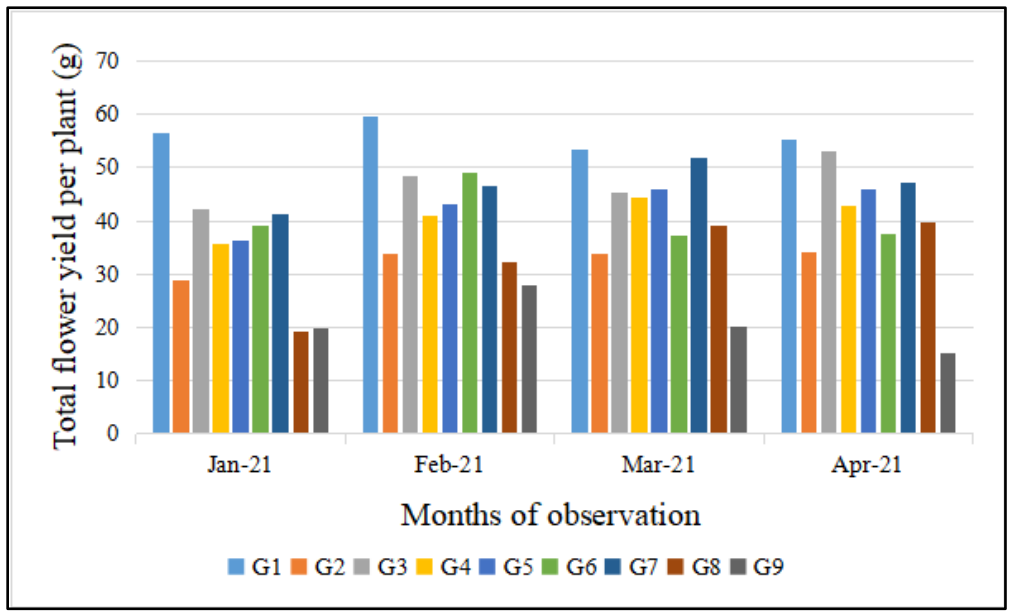


Figure 24. Effect of growth regulators on total flower yield

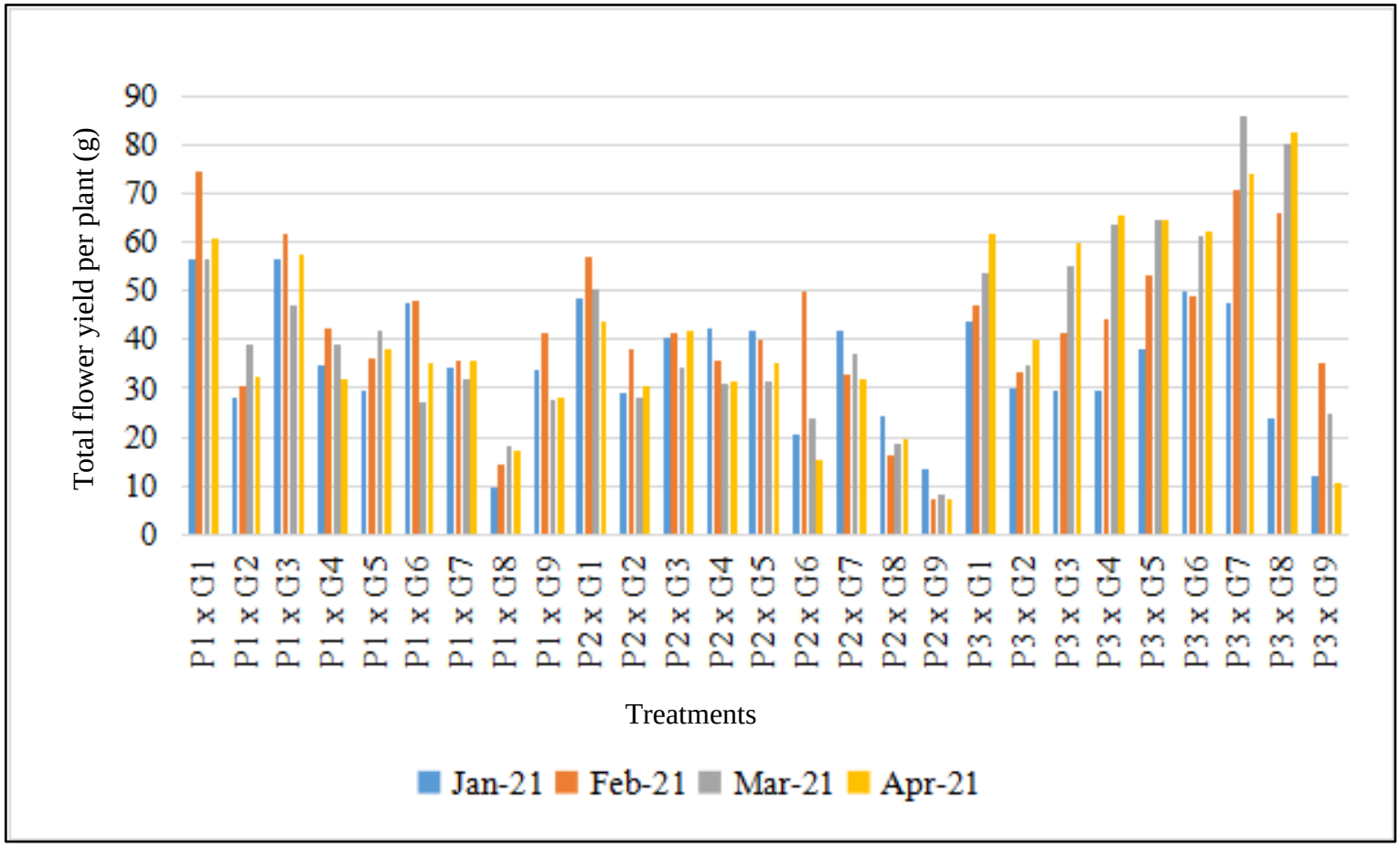


Figure 25. Effect of P x G on Total flower yield per plant

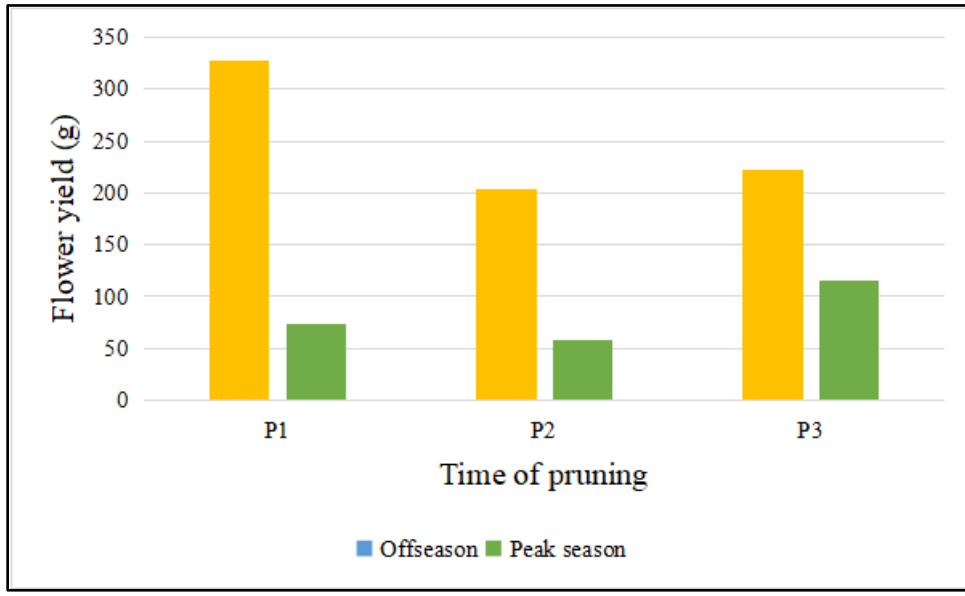


Figure 26. Effect of time of pruning on flower yield during offseason and peak season

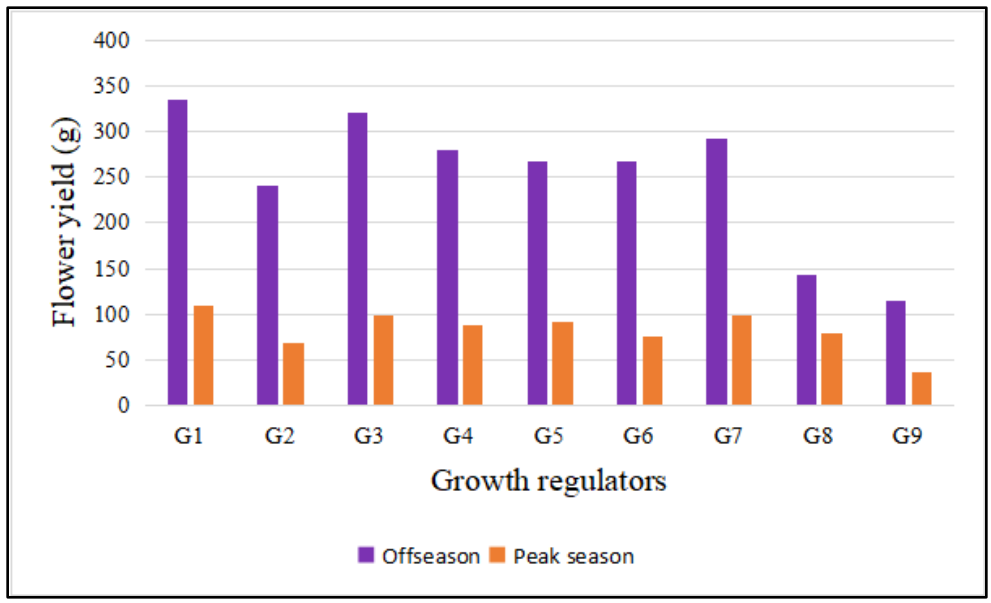


Figure 27. Effect of growth regulators on flower yield during offseason and peak season

Reduced level of endogenous gibberellins might be a prerequisite for floral induction which was achieved by spraying of growth retardants such as cycocel and paclobutrazol. Similar results were also noticed in other crops like African marigold when treated with cycocel as reported by Sunayana *et al.* (2018), Sikarwar (2021) and in sunflower by Patil *et al.* (1997). The results are in conformity with that reported by Sudhagar *et al.* (2017) and Gowda *et al.* (1991) in *Jasminum sambac*. Dhanasekharan (2018) noticed higher yield in *Jasminum sambac* plants treated with GA_3 at a concentration of 150 ppm. According to Sobhana (2014) plants treated with cycocel and GA_3 gave the highest yield in *Jasminum sambac*. Srivastava *et al*. (2001) stated that application of GA_3 increased the yield in *Jasminum sambac*.

5.5.3. Interaction effect of time of pruning and growth regulators

Interaction effect of P x G was found to have significant influence with respect to flower yield during off-season and flower yield during peak season. P_1 x G_1 (pruning during last week of September along with cycocel at 1000 ppm) gave a higher yield (572.57 g) when compared with other treatments during off-season (Figure 28). Whereas during peak season P_3 x G_8 (pruning during last week of November along with GA_3 at 150 ppm) and P_3 x G_7 (pruning during last week of November along with application of GA_3 at 100 ppm) were found to be superior in terms of flower yield (Figure 28).

Application of cycocel resulted in reduction of endogenous gibberellin which is a prerequisite for flower induction in flowering plants, when combined with early pruning (pruning during last week of September) gave sufficient time period for the plant to put forth energy into vegetative production and later flower production which can be stated as reason for more flower yield during off-season in P_1 x G_1 combination. Whereas application of GA_3 along with late pruning (during last week of November) might be attributed to the enhanced vegetative growth during off-season, which would have favoured the increased photosynthesis and CO_2 fixation. Further, it would have favoured convenience of factors influencing floral initiation during peak season ie., carbohydrate pathway and photoperiodic pathway with GA_3 pathway (Dhanasekharan,

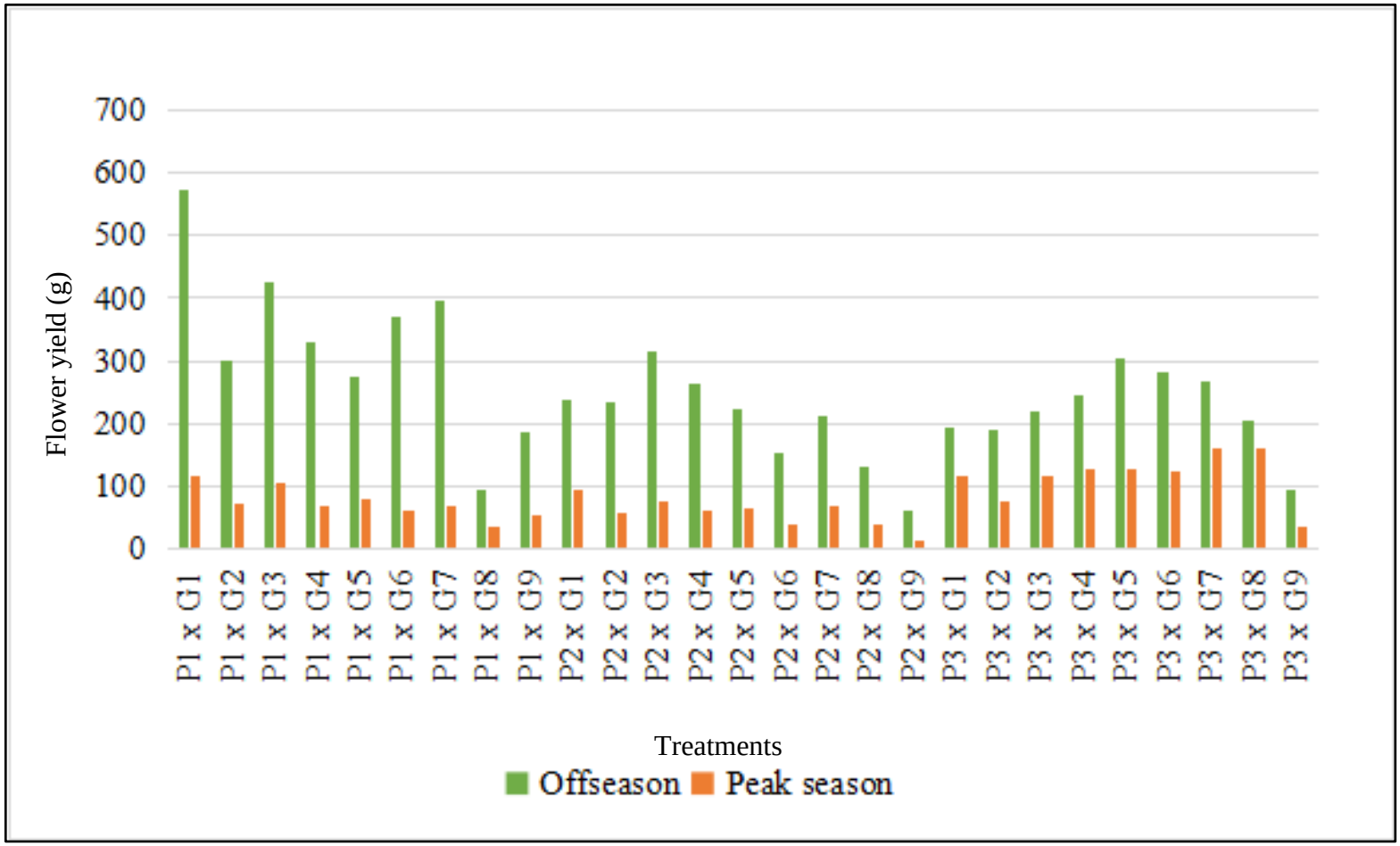


Figure 28. Effect of P x G on flower yield during offseason and peak season

2018). The findings of the study are also in accordance with the findings of Baskaran *et al*. (2007) in Gladiolus.

5.6. PEST AND DISEASES

Major pest observed affecting jasmine was jasmine midge *(Contarinia maculipennis)*. The incidence of pest was high during February 21 to March 21. Affected flower buds failed to open and turned purple in colour before completely dried. All treatments were susceptible to Jasmine midge attack. The higher incidence of flower midge may be due to the prevailing hot humid condition during these months. Infestation of jasmine midge were in Andhra pradesh (David *et al.,* 1990). Application of Fipronil 2ml/ Litre and removal of infected cymes were appreciable in controlling and regulating infestation in *Jasminum sambac*.

The major disease affected was bacterial wilt and was fatal for the affected plants. Sanitisation of the field and drenching with Saaf at 2ml/ Litre was found to be effective in managing the disease.

Summary

6. SUMMARY

A study entitled “Induction of off-season flowering in jasmine (*Jasminum sambac* L.) was carried out at the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara. The experiment consists of 27 treatment combinations which were laid out in RBD (with two factors) in two replications. Pruning is done during three different time of the year *viz.* during last week of September (P_1), last week of October (P_2) and last week of November (P_3); along with the applications of growth regulators in two levels *viz.* cycocel (1000 ppm, 1500 ppm), paclobutrazol (200 ppm, 300 ppm), mepiquat chloride (150 ppm, 300 ppm) and GA_3 (100 ppm, 150 ppm). The salient findings of the study are summarised below.

Pruning have a significant influence on growth and flowering of jasmine. With regard to plant height, pruning during last week of September (P_1) was found to have the greatest plant height except in the month of June, where plants pruned during last week of October (P_2) had more plant height (117.46 cm). And the lowest plant height was noticed in plants pruned during last week of November (P_3) throughout the month of study. Growth regulators had significant influence regarding this parameter during the months of January and February. Treatments cycocel at 1000 ppm (G_1), paclobutrazol at 200 ppm (G_3), GA_3 at 100 ppm (G_7), GA_3 at 150ppm (G_8) along with control (G_9) were on par in terms of plant height (83.50, 80.11, 82.08, 91.17,88.16 and 77.58 cm respectively). Among different levels of growth regulators, treatment with mepiquat chloride produced the shortest plants.

When considering effect of time of pruning on plant spread, the highest plant spread was observed in plants pruned during last week of September (P_1) and last week of October (P_2) during the months of February and March. The number of secondary branches was influenced by the application of growth regulators and plants treated with cycocel at 1000 ppm (G_1) and cycocel at 1500 ppm (G_2) were on par in terms of this parameter. There was no significant influence noticed in vegetative parameters due to the interaction effect of time of pruning and application of growth regulators.

There was no significant influence noticed on physiological parameters when pruning was done at three different time of this year. But the application of growth regulators was found to have significant influence on physiological parameters. Specific leaf area was significantly higher in untreated plants (G_9) (198.86 cm^2/ g) whereas chlorophyll content was significant among the treatments G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm)(1.285 mg/ g and 1.273 mg/ g). The interaction effect between time of pruning and application of growth regulators didn't have any significant influence in terms of this parameter.

Days to first flower bud initiation was found to be less in plants (17.96) pruned during last week of November (P_3) and it significantly varied when growth regulators were treated. G_1 (cycocel 1000 ppm) and plants treated with G_4 (paclobutrazol 300 ppm) were on par (11.01 and 9.01 days respectively) in terms of this parameter. The interaction effect between P x G had a significant effect on the number of days taken for bud initiation. Treatments P_1 x G_3 (pruning during last week of September along with drenching of paclobutrazol at 200 ppm), P_1 x G_4, (pruning during last week of September along with drenching of paclobutrazol at 300 ppm) P_2 x G_1 (pruning during last week of October along with spraying of cycocel at 1000 ppm), P_2 x G_2 (pruning during last week of October along with spraying of cycocel at 1500 ppm), P_2 x G_3 (pruning during last week of October along with drenching of paclobutrazol 200 ppm) and P_2 x G_4 (pruning during last week of October along with drenching of paclobutrazol at 300 ppm), P_3 x G_3 (pruning during last week of November along with drenching of paclobutrazol 200 ppm), P_3 x G_4 (pruning during last week of November along with drenching of paclobutrazol 300 ppm) were found to be on par (8.66, 11.38, 13.5, 12.16, 8.33, 10.16, 10.16 and 11.5 days respectively). The days for bud initiation ranged from 8.33 days to 59.33 days. The treatment combination P_1 x G_8 (pruning during last month of September along with spraying of GA_3 at 150 ppm), P_1 x G_9 (pruning during last month of September without treatment of growth regulators) took more days for bud initiation.

Pruning time had a significant influence on the number of cymes per plant in the months of February to April. Plants pruned during last week of November (P_3) showed on par with plants pruned during last week of September (P_1) during the month

of February with respect to number of cymes per plant. In the month of March and April plants pruned during last week of November (P_3) showed significantly highest number of cymes per plant (80.66 and 74.34 respectively). Lowest number of cymes per plant was observed in plants pruned during last week of October (P_2) throughout the period of observation. Growth regulators had a significant influence on the number of cymes per plant throughout the study period. G_1 (cycocel 1000 ppm) (65.16, 74.55, 90.61 and 78.29 respectively) and G_3 (Paclobutrazol 200 ppm) (56.86, 67.83, 76.30 and 73.80 respectively) were found to be on par throughout the experiment period along with G_7 (GA_3 100 ppm) during January (49.11) and February (60.44). During the months February, March and April G_4 (paclobutrazol 300 ppm) expressed significance with values 57.44, 71.75 and 66.25 and were on par with G_5 (Mepiquat chloride 150 ppm) during the months of February (55. 89) and April (66.25). P x G interaction was found to have a significant influence on the yield parameter *viz*. number of cymes per plant during the months of January and April. In January the number of cymes per plant ranged from 9.67 to 87.83 and in April it ranged from 11.95 to 96.88. During the month of January, P_1 x G_1 (pruning during last week of September along with cycocel at 1000 ppm), P_1 x G_3 (pruning during last week of September along with paclobutrazol at 200 ppm), P_1 x G_6 (pruning during last week of September along with mepiquat chloride at 150 ppm), P_2 x G_1 (pruning during last week of October along with cycocel 1000 ppm), P_1 x G_3 (pruning during last week of October along with paclobutrazol 200 ppm), P_2 x G_5 (pruning during last week of October along with mepiquat chloride at 150 ppm), P_3 x G_1 (pruning during last week of November along with cycocel 1000 ppm) and P_3 x G_3 (pruning during last week of November along with paclobutrazol at 200 ppm) were found to be on par (87.83, 73.33, 57.08, 57.16, 61.41, 56, 65.16, and 56. 85 respectively) with respect to number of cymes per plant. During the month of April P_1 x G_1 (pruning during last week of September along with cycocel at 1000 ppm), P_1 x G_3 (pruning during last week of September along with paclobutrazol at 200 ppm), P_3 x G_3 (pruning during last week of November along with paclobutrazol at 200 ppm), P_3 x G_4 (pruning during last week of November along with paclobutrazol at 200 ppm), P_3 x G_5 (pruning during last week of November along with mepiquat chloride at 150 ppm), P_3 x G_6 (pruning during last week of November along with mepiquat chloride 300 ppm), P_3 x G_7 (pruning during last week of November along with GA_3 at 100 ppm) and P_3 x G_8

(pruning during last week of November along with GA_3 at 150 ppm) found to be on par (96.88, 79.83, 82.33, 81.91, 98.25, 91.75, 76.16, 77.5 and 82.16 respectively).

The number of buds per plant was significantly higher in plants pruned during last week of November (P_3) during February, March and April months of observation (226.92, 297.67 and 260.31 respectively). The number of buds per plant was found to be on par in plants pruned during last week of September (P_1) and plants pruned during last week of November (P_3) during the month of February. Plants treated with G_1 (cycocel 1000 ppm) and G_3 (paclobutrazol 200 ppm) were found to be significantly superior in terms of number of buds per plant (324.77 and 283.34 respectively).It was evident that the P x G interaction had a significant effect on the number of buds per plant in the months of January and April. In month of January P_1 x G_1 (pruning during last week of September along with cycocel at 1000 ppm) (313.16), P_1 x G_3 (pruning during last week of September along with paclobutrazol at 100 ppm) (258), P_2 x G_1 (pruning during last week of October along with cycocel at 1000 ppm) (211), P_2 x G_5 (pruning during last week of October along with cycocel at mepiquat chloride at 150 ppm) (206.75) and P_3 x G_7 (pruning during last week of November along with GA_3 at 100 ppm) (234.83) were found to be on par. In the month of April, all treatments except P_3 x G_2 (pruning during the last week of November along with cycocel at 1500 ppm) and P_3 x G_9 (pruning during the last week of November without growth regulator application) were found to be significant among P_3 x G combinations and was on par with P_1 x G_1 (pruning during last week of September along with cycocel at 1000 ppm) (311.83) P_1 x G_3 (pruning during last week of September along with paclobutrazol at 100 ppm) (293.73).

Weight of 100 flowers was significantly higher in plants treated with G_7 (GA_3 100 ppm) in January (26.26 g), February (26.16 g) and March (26.33 g) and G_8 (GA_3 150 ppm) in January (26.38 g), March (26.33 g) and April (26.72 g). In terms of corolla tube length treatment with G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm), G_3 (paclobutrazol 200 ppm), and G_8 (GA_3 150 ppm) had a positive influence and were on par.

When studied the effect of time of pruning on length of flower bud showed a significant influence only in the month of March. P_1 (pruning during the last week of September) showed significantly higher value for length of flower bud (11.44 mm) in jasmine plants. The growth regulator application had significant effect on the length of flower bud only in the month of February. In the month of February except for G_9 (Control) application of growth regulators show a significant difference in terms of length of flower bud (G_1 -11.26, G_2 - 11.11, G_3 - 11.25, G_4 - 11.21, G_5 - 11.16, G_6 - 11.57, G_7 - 11.27 and G_8 - 11. 12). The individual effect of time of pruning and application of growth regulators and the interaction effect of P x G was found to be non-significant in terms of width of flower.

When the effect of time of pruning on corolla tube length was studied it was found to have no specific influence on the parameter. The influence of growth regulators in the month of January, G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm), G_3 (paclobutrazol at 200 ppm) and G_8 (GA_3 150 ppm) were found to be on par (11.49, 11.46, 10.96 and 11.15 mm respectively). In the month of February G_1 (cycocel 1000 ppm) (11.29 mm) and G_2 (cycocel 1500 ppm) (11.35 mm) were on par. In the month of March and April G_2 (cycocel at 1500 ppm) was found to show superior results (11.96 and 11.68 mm respectively). G_9 (control) showed the lowest corolla tube length throughout the period of study (10.22, 10.87, 10.57 and 10.58 mm respectively). P x G interaction had a significant effect on the corolla tube length of the flower. In the month of January, P_1 x G_2 (pruning during the last week of September along with cycocel at 1500 ppm) (11.59 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 at 100 ppm) (11.73 mm), P_1 x G_9 (11.81 mm), P_2 x G_1 (pruning during the last week of October along with cycocel at 1000 ppm) (11.79 mm), P_3 x G_2 (pruning during the last week of November along with cycocel at 1500 ppm) (11.72 mm) were found to be on par. In the month of February P_1 x G_8 (pruning during the last week of September along with GA_3 at 150 ppm) (11.76 mm) and P_3 x G_2 (pruning during the last week of November along with cycocel at 1500 ppm) (11.82 mm) were found to be significantly superior. During march P_1 x G_7 (pruning during the last week of September along with GA_3 at 100 ppm) (11.93 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 at 150 ppm)(11.93 mm), P_2 x G_1 (pruning during the last week of October

along with cycocel at 1000 ppm) (11.69 mm), P_3 x G_1 (pruning during the last week of November along with cycocel at 1000 ppm) (11.61 mm) and P_3 x G_6 (pruning during the last week of November along with mepiquat chloride at 300 ppm) (11.46 mm) were found to be on par. In April P_1 x G_6 (pruning during the last week of September along with mepiquat chloride at 300 ppm) (11.69 mm), P_1 x G_8 (pruning during the last week of September along with GA_3 at 150 ppm) (11.85 mm), P_2 x G_5 (pruning during the last week of October along with mepiquat chloride at 150 ppm) (11.61 mm) and P_3 x G_5 (pruning during the last week of November along with mepiquat chloride at 300 ppm) (11.49 mm) were on par.

No significant influence of pruning time, application of growth regulators and P x G interaction could be observed with respect to corolla tube girth during the entire period of observation.

Plants pruned during last week of September (P_1) and plants pruned during last week of November (P_3) were on par in terms of flower yield during the month of January (42.79 g and 48.93 g respectively); plants pruned during last week of November (P_3) was superior in the months of March and April. G_1 (cycocel at 1000 ppm) (56. 56, 59.55, 53.49 and 55.35 g), G_3 (paclobutrazol at 200 ppm) (42.13, 48.32, 45.41 and 53.01 g) and G_7 (GA_3 at 100 ppm) (41.103, 46.5, 51.66 and 47.3 g) were on par from January to April in terms of total yield per plant. Interaction effect on total flower yield showed that P_1 x G_1 (pruning during the last week of September + cycocel at 1000 ppm) (74.67 g), P_1 x G_3 (pruning during the last week of September + paclobutrazol at 200 ppm) (61.95 g), P_3 x G_7 (pruning during the last week of November + GA_3 at 100 ppm) (74.29 g) and P_3 x G_8 (pruning during the last week of November + GA_3 at 150 ppm) (82.50 g) gave the significant result.

During off-season, significant yield was found in plants pruned during last week of September (P_1) whereas during peak season pruning during last week of November (P_3) gave superior results (328.01 g and 222.76 g respectively). In relation to effect of growth regulators on yield parameters, significant effect was noticed for, yield during off-season and yield during peak season. During off-season G_1 (cycocel 1000 ppm), G_3 (paclobutrazol 200 ppm) and G_7 (GA_3 100 ppm) gave the superior result (335.42,

320.43 and 292.07 g respectively) whereas during peak season in G_1 (cycocel 1000 ppm), G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm) (108.85, 98.41 and 98.96 respectively) were found to exhibit significant yield. In terms of yield during off-season, interaction effect of P_1 x G_1 (pruning during the last week of September + cycocel at 1000 ppm) gave a higher yield (572. 57 g) when compared with other treatment combinations.

There was a significant difference among the different pruning times with regard to flower yield per plant during peak season. Pruning during the last week of November (P_3) was found to have superior results (116.13 g) in terms of flower yield per plant during peak season followed by pruning during the last week of September (P_1) (73.77 g). The lowest flower yield was observed in pruning during the last week of October (P_2) (57.68 g). G_1 (cycocel 1000 ppm) (108. 85 g), G_3 (paclobutrazol 200 ppm) (98.42 g) and G_7 (GA_3 100 ppm) (98.96 g) were on par when treated with different growth regulators. The lowest yield was noticed in G_9 (Control) (35.46 g). In interaction of P x G, P_3 x G_8 (pruning during the last week of November + GA_3 at 100 ppm) and P_3 x G_7 (pruning during the last week of November + GA_3 at 150 ppm) were found to be on par during peak season (162.54 g and 160.7 g respectively).

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Appendices

APPENDIX - I

Meteorological data during the period of observation from April 2020 to April 2021

Monthly data (2020-2021)						
	Temperature (°C)		RH (%)			Rainfall (mm)
Month	Max.	Min.	I	II	Mean	
April-20	36.4	24.7	86	55	71	44.7
May	35.0	25.2	90	63	77	59.6
June	31.1	23.7	94	75	85	427.2
July	30.5	23.2	96	78	87	563.0
August	30.2	23.1	96	77	87	607.7
September	30.0	22.4	96	80	88	587.6
October	31.0	21.5	95	69	82	310.3
November	33.0	22.0	84	57	71	56.1
December	32.0	21.9	75	55	65	7.7
January	32.3	21.3	78	50	64	45.7
February	34.6	21.6	70	38	54	0.0
March	36.8	23.0	84	34	59	31.8
April-21	34.9	23.6	89	58	74	72.4

INDUCTION OF OFF-SEASON FLOWERING IN JASMINE (*Jasminum sambac* L.)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Jasminum sambac L. is an important commercial loose flower crop cultivated for fresh flowers and for concrete extraction. Due to seasonal flowering nature of jasmine glut during the peak season and scarcity of flowers during off-season is usually observed, which creates fluctuations in the price of the crop. So regulation of flower production according to market needs is very essential in jasmine. It is in this respect that the possibility of using the combination of pruning with plant growth regulators for regulation of flowering in jasmine assumes significance.

The study entitled "Induction of off-season flowering in jasmine (*Jasminum sambac* L.)" was conducted at the Department of Floriculture and Landscape Architecture at the College of Agriculture, Vellanikkara during 2020-21. The objective of the study was to evaluate the effects of growth regulators and pruning on induction of off-season flowering in jasmine (*Jasminum sambac* L.). The experiment was laid out in RBD (with two factors) in two replications. Pruning is done during three different time of the year *viz.* during last week of September (P_1), last week of October (P_2) and last week of November (P_3); along with the applications of growth regulators in two levels *viz.* cycocel (1000 ppm, 1500 ppm), paclobutrazol (200 ppm, 300 ppm), mepiquat chloride (150 ppm, 300 ppm) and GA_3 (100 ppm, 150 ppm).

Growth parameters such as plant height, plant spread, number of primary branches and number of secondary branches, physiological characters such as specific leaf area, chlorophyll a, chlorophyll b and total chlorophyll content of leaves; flowering and yield parameters like number of flowers buds per cyme, number of cymes per plant, number of flower buds per plant, weight of hundred flower buds, flower yield per plant, length of flower bud, width of flower bud, corolla tube length, corolla tube girth, flower yield per plant during offseason and peak season were observed.

Pruning have a significant influence on growth and flowering of jasmine. There was a significant variation with respect to vegetative parameters *viz*. plant height and plant spread. Pruning during last week of September (P_1) was superior in terms of vegetative parameters such as plant height and plant spread throughout the period of study. During June 21, plants pruned during last week of October (P_2) were found to be

on par with plants pruned during last week of September (P_1) in terms of plant height. Influence of pruning on plant spread was only significant during the months of February and March, plants pruned during last week of September (P_1) were found to be on par with plants pruned during last week of October (P_2). There was no significant influence noticed on physiological parameters when pruning was done at three different time periods. Days to first flower bud initiation was found to be less in plants (17.96) pruned during last week of November (P_3). The number of buds per plant was significantly higher in plants pruned during last week of November (P_3) during February, March and April months of observation (226.92, 297.67 and 260.31 respectively). The number of buds per plant was found to be on par in plants pruned during last week of September (P_1) and plants pruned during last week of November (P_3) during the month of February. Plants pruned during last week of September (P_1) and plants pruned during last week of November (P_3) were on par in terms of flower yield during the month of January (42.79 g and 48.93 g respectively); plants pruned during last week of November (P_3) was superior in the months of March and April. During offseason significant yield was found in plants pruned during last week of September (P_1) whereas during peak season pruning during last week of November (P_3) gave superior results (328.01 g and 116. 13 g respectively).

Influence of growth regulators was studied and found significant effect with respect to plant height and number of secondary branches. The treatments G_1 (cycocel 1000 ppm), G_3 (paclobutrazol 200 ppm), G_4 (paclobutrazol 300 ppm), G_7 (GA_3 100 ppm), G_8 (GA_3 150 ppm) and G_9 (untreated plants) were found to be on par in terms of this parameter. Specific leaf area was significantly higher in untreated plants (G_9) (198.86 cm^2/ g) whereas chlorophyll content was significant among the treatments G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm)(1.285 mg/ g and 1.273 mg/ g). Days to bud initiation was significantly varied and G_1 (cycocel 1000 ppm) and plants treated with G_4 (paclobutrazol 300 ppm) were on par (11.01 and 9.01 days respectively). Plants treated with G_1 (cycocel 1000 ppm) and G_3 (paclobutrazol 200 ppm) were found to be significantly superior in terms of number of cymes per plant (78.79 and 76.30 respectively) and number of buds per plant (324.77 and 283.34 respectively). Weight of 100 flowers was significantly higher in plants treated with G_7 (GA_3 100 ppm) in January (26.26 g), February (26.16 g) and March (26.33 g) and G_8 (GA_3 150 ppm) in

January (26.38 g), March (26.33 g) and April (26.72 g). In terms of corolla tube length treatment with G_1 (cycocel 1000 ppm), G_2 (cycocel 1500 ppm), G_3 (paclobutrazol 200 ppm), and G_8 (GA_3 150 ppm) had a positive influence and were on par. Even though no significance was noticed in other quality parameters the application of growth retardants had a positive influence on quality parameters compared to control. In relation to effect of growth regulators on yield parameters, significant effect was noticed for total flower yield, yield during offseason and yield during peak season. G_1 (cycocel at 1000 ppm) (56. 55, 59.54, 53.5 and 55.35 g), G_3 (paclobutrazol at 200 ppm) (42.13, 48.31, 45.41 and 53.01 g) and G_7 (GA_3 at 100 ppm) (41.103, 46.5, 51. 66 and 47.3 g) were on par from January to April in terms of total yield per plant. During offseason G_1 (cycocel 1000 ppm), G_3 (paclobutrazol 200 ppm) and G_7 (GA_3 100 ppm) gave the superior result (335.42, 320.43 and 292.07 g respectively) whereas during peak season in G_1 (cycocel 1000 ppm), G_3 (paclobutrazol 200 ppm) and G_4 (paclobutrazol 300 ppm) (108.85, 98.41 and 98.96 respectively) were found to exhibit significant yield.

Considering the interaction effect of time of pruning and application of growth regulators, parameters like days to bud initiation, number of cymes per plant, number of buds per plant, corolla tube length, total flower yield per plant and flower yield during offseason and peak season showed a significant influence. Treatments P_1 x G_3 (pruning during last week of September + drenching of paclobutrazol at 200 ppm), P_1 x G_4 (Pruning during last week of September + drenching of paclobutrazol 300 ppm), P_2 x G_1 (pruning during last week of October + spraying of cycocel at 1000 ppm), P_2 x G_2 (Pruning during last week of October + cycocel at 1500 ppm), P_2 x G_3 (pruning during last week of October + paclobutrazol 200 ppm), P_2 x G_4 (Pruning during last week of October + paclobutrazol at 300 ppm), P_3 x G_3 (Pruning during last week of November + paclobutrazol 200 ppm) and P_3 x G_4 (Pruning during last week of November + paclobutrazol at 300 ppm) were found to be on par (8.66, 11.38, 13.5, 12.16, 8.33, 10.16, 10.16 and 11.5 days respectively) in terms of number of days taken for flower bud initiation. Interaction effect on total flower yield showed that P_1 x G_1 (pruning during the last week of September + cycocel at 1000 ppm) (77.66 g), P_1 x G_3 (pruning during the last week of September + paclobutrazol at 200 ppm) (61.95 g), P_3 x G_7 (pruning during the last week of November + GA_3 at 100 ppm) (74.29 g) and P_3 x G_8 (pruning during the last week of November + GA_3 at 150 ppm) (82.50 g) gave the

significant result. In terms of yield during offseason interaction effect of P_1 x G_1 (pruning during the last week of September + cycocel at 1000 ppm) gave a higher yield (572. 57 g) when compared with other treatment combinations. P_3 x G_8 (pruning during the last week of November + GA_3 at 100 ppm) (162.57 g) and P_3 x G_7 (pruning during the last week of November + GA_3 at 150 ppm) (160. 54 g) were found to be on par during peak season.

Considering the overall effect in induction of offseason flowering in jasmine, combination of pruning during last week of September along with the application of cycocel (1000 ppm) or paclobutrazol (200 ppm) gave the best result.