

**“EFFECT OF PLANT GROWTH RETARDANTS ON THE GROWTH,
FLOWERING AND YIELD OF HELICONIA (*Heliconia psittacorum*)
VAR. RED TORCH UNDER 50 PER CENT SHADE NET CONDITION”**

A

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IN

FLORICULTURE AND LANDSCAPE ARCHITECTURE

BY

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ABSTRACT

**EFFECT OF PLANT GROWTH RETARDANTS ON THE
GROWTH, FLOWERING AND YIELD OF HELICONIA (*Heliconia
psittacorum*) VAR. RED TORCH UNDER 50 PER CENT SHADE
NET CONDITION.**

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ABSTRACT

The present investigation to study the “Effect of plant growth retardants on the growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 per cent shade net condition” was carried out at Floriculture Research Farm, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture & Forestry, Navsari Agricultural University, Navsari in the year 2012-2013.

The experiment was laid out in Randomized Block Design (RBD) having nine treatments of plant growth retardants with different concentrations *viz.* CCC @ 100 ppm (T₁), CCC @ 200 ppm (T₂), MH @ 25 ppm (T₃), MH @ 50 ppm (T₄), TIBA @ 15 ppm (T₅), TIBA @ 30 ppm (T₆), PCB @ 150 ppm (T₇), PCB @ 300 ppm (T₈) and water drenching as control (T₉).

The experimental results revealed that among all growth retardants, drastically suppressed plant height was recorded with paclobutrazol @ 300 ppm i.e. T₈ (24.86 cm, 25.95 cm, 27.20 cm

and 49.60 cm, respectively) and it was on par with paclobutrazol @ 150 ppm i.e. T₇ (25.73 cm, 26.76 cm, 28.40 cm and 54.33 cm, respectively), followed by TIBA @ 30 ppm (59.53 cm, 103.15 cm, 133.46 cm and 140.26 cm, respectively) at 3, 6, 9 and 12 MAP. Other vegetative parameters like maximum number of leaves per plant (4.60, 6.20, 4.66 and 4.33) at 3, 6, 9 and 12 MAP, respectively and number of suckers per clump (6.13, 12.20 and 15.86) at 6, 9 and 12 MAP, respectively were found in plants treated with MH @ 50 ppm (T₄). The maximum leaf area (477.73 cm² at 12 MAP) was found with the application of MH @ 50 ppm (T₄), which was frequently on par with CCC @ 100 ppm (T₁) and MH @ 25 ppm (T₃).

Regarding flowering and yield attributes, minimum days to flowering (147.20), maximum flowering duration (55.40 days), highest number of bracts and florets (4.60 and 12.06, respectively), longest rachis length and stalk length (15.41 cm and 110.98 cm, respectively), spikes per clump, per plot and per 1000 m² (4.46, 35.66 and 5572.92, respectively) and vase life (13.33 days) found in plants treated with maleic hydrazide @ 50 ppm (T₄), which was commonly on par with CCC @ 100 ppm (T₁) in all flowering parameters. Regarding overall presentability of heliconia spike, maximum score (10) was obtained in plants treated with MH @ 50 ppm.

As far as chemicals concerned, maximum chlorophyll content (0.14 mg/g), anthocyanin (0.08 mg/g) and total soluble sugar (171.24 mg/g) was also found in MH @ 50 ppm.

Same treatment was found beneficial for economics of heliconia spikes with maximum net return (Rs. 49025.51 per 1000 m²), BCR of 1.19 and it was followed by MH @ 25 ppm and CCC @ 100 ppm with net return (Rs. 41883.72 and Rs. 41334.72, respectively) and BCR (1.02 and 0.95, respectively) per 1000 m².



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CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF *PLAN* GROWTH RETARDANTS ON THE GROWTH, FLOWERING & YIELD OF HELICONIA (*Heliconia psittacorum*) VAR. RED TORCH UNDER 50 PER CENT SHADE NET CONDITION**" submitted by **MISS. JADHAV SHEETALBEN KIRTIKUMAR** in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in the subject of **FLORICULTURE AND LANDSCAPE ARCHITECTURE** of the Navsari Agricultural University is a record of bonafide research work carried out by her under my guidance and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari

Date : 13/05/2013

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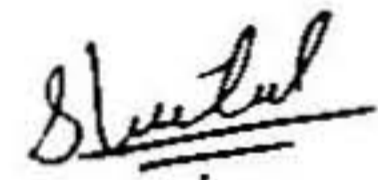

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DECLARATION

This is to certify that the whole of the research work submitted in this thesis for the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in the subject of **FLORICULTURE AND LANDSCAPE ARCHITECTURE** is the result of investigation done by the undersigned under the direct guidance and supervision of **Dr. S. L. Chawla**, Associate Professor (Floriculture), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

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LIST OF ABBREVIATION AND SYMBOLS

| Sr. No. | Abbreviation | Meaning |
|---------|------------------|------------------------------|
| 1 | % | Per cent |
| 2 | °C | Degree Celsius |
| 3 | C. D. | Critical difference |
| 4 | C. V. | Co- efficient of variance |
| 5 | S. Em. \pm | Standard error of mean |
| 6 | var. | Variety |
| 7 | MT | Metric ton |
| 8 | G | Gram |
| 9 | Mg | Milligram |
| 10 | <i>Viz,</i> | Namely |
| 11 | cv. | Cultivar |
| 12 | Ppm | Parts per million |
| 13 | L | Litre |
| 14 | <i>et al.</i> | <i>Et alii</i> (and others.) |
| 15 | <i>i.e.</i> | that is |
| 16 | ml | Milliliter |
| 17 | mg/l | Milligram per litre |
| 18 | a.i. | Active ingredient |
| 19 | ha ⁻¹ | Per hectare |
| 20 | ml/l | Milliliter per litre |
| 21 | Cm | Centimeter |
| 22 | Mm | Millimeter |
| 23 | cm ² | Square centimeter |
| 24 | m ² | Square meter |

Cont... List of abbreviation and symbols

| Sr. No. | Abbreviation | Meaning |
|---------|--------------|---------------------------------|
| 25 | BCR | Benefit cost ratio |
| 26 | Rs. | Rupees |
| 27 | M | Meter |
| 28 | Kg | Kilogram |
| 29 | Fig. | Figure |
| 30 | @ | at the rate |
| 31 | pH | Potential of H ⁺ ion |
| 32 | MAP | Months after planting |
| 33 | RBD | Randomized block design |
| 34 | PGRs | Plant growth regulators |
| 35 | CCC | Cycocel |
| 36 | MH | Maleic hydrazide |
| 37 | TIBA | Tri iodo benzoic acid |
| 38 | PCB | Paclobutrazol |
| 39 | DMSO | Di methyl sulphoxide |
| 40 | w/w | Weight by weight |
| 41 | w/v | Weight by volume |
| 42 | Nm | Nanometer |
| 43 | TSS | Total soluble sugar |



INTRODUCTION

I. INTRODUCTION

Floriculture has been associated with culture and heritage since ancient time in our country. Besides, flowers have also been known to enhance the creative ability and work performance in human beings. They are the most beautiful part of nature and have the power to overwhelm anybody's heart with joy, happiness and love. By gradual urbanization, commercial floriculture is today a potential money-spinner and an economically viable agri-business. With increasing modernization, India has potential to emerge as significant player of the flora industry in future.

A consistent increase in demand for cut flowers has made floriculture one of the most important commercial trade in Indian agriculture. Emphasis has been shifted from traditional flowers to cut flowers for export purpose. India is bestowed upon with rich bio-diversity of ornamental crops. Its varied agro-climate, ample sunshine and proximity to the markets of the Middle East and South Asian countries offer great opportunities to harness the potential in floriculture and ornamentals. About 2,53,650 ha area in India is under floriculture producing 16,51,610 metric tons of loose flowers and 75065.98 lakh numbers of cut flowers during 2011-12. The overall exports of floricultural produce from India had touched Rs. 28,645.4 lakh by the end of 2010-11. The leading flower growing states in India are Paschimbanga, Tamil Nadu, Maharashtra, Andhra Pradesh and Karnataka. (Anonymous, 2012).

Floriculture in Gujarat is also flourishing well and cut flower cultivation under protected cultivation has increased at a fast pace. The area under protected cultivation has been reported to be of 150 acres and around 300 green houses were established. The state is producing around 49.5 thousand MT of loose flowers, 5,063 lakh cut flowers (Anonymous, 2011). The important loose flower crops are rose, chrysanthemum, tuberose, jasmine, marigold, gaillardia and spider lily where as the cut flowers like rose, gerbera, gladiolus are mainly grown in Gujarat. It has a suitable climatic condition to grow high value flower crops like, heliconia, orchid, bird of paradise and anthurium, etc.

In the background of bright prospects for domestic as well as export market of floricultural products, with a strategy of developing a road map towards the progress in Indian floriculture, it is felt that more research and development efforts are to be concentrated on developing high yielding varieties with year round production.

Heliconia is an important cut flower crop and tropical rhizomatic herbaceous perennial plant belongs to family Heliconiaceae which is member of a large taxonomic category called the order Zingiberales. Heliconias are native to Central and South America, the Caribbean Islands and some of the Islands of the South Pacific. In our country, West Godavari district of Andhra Pradesh, Kerala, Karnataka, Assam and other North-Eastern states are the major producers. It has several common names like 'Lobster's Claws', 'Parrot's Flower', 'Parrot Plantain'

and 'False Plantain'. These flowers are the most unusual flora of the tropics and gaining popularity as commercially high value cut flower due to the diversity in their color, form, unusual inflorescence and long lasting vase life.

Many varieties of heliconia come up well under partial shade making them ideal as inter crop in coconut gardens. In tropical areas, heliconias are growing well under 40-50 per cent shade (Sheela *et al.*, 2006). *Heliconia psittacorum* var. 'Red Torch' which was taken for experiment is considered under dwarf group. This variety has red colored stem along with attractive dark red bracts and bright yellow florets. It has erect and distichous type of flower growing pattern. It is used in landscaping, as a pot plant, cut flower, flower arrangement, bouquets, etc. The leaves are used for roof thatching as well as food wrappers in some countries. It is sought by consumers due to the energetic and lively bract and florets color, which are often vibrant and contrasting.

The growth and yield of plants are mainly influenced by two principle factors *viz.* genetic and cultivation or management. In recent years, scientists have given attention to the idea of regulating plant growth with the application of plant growth regulators in various ways for improving the yield and flower quality as the third most important factor. Various growth regulators, especially growth retardants are synthetic compounds used to retard the shoot length of the plant without evoking phytotoxic effects. This has been achieved not only by reducing the cell elongation but also by lowering the rate of cell division

and regulating the plant height physiologically (Rademacher, 1995). Various methods are being tried out for retarding the rate of plant growth and increasing more number of quality flowers for getting more profit. Most of the available growth retardants are anti gibberellins, as they inhibit the growth active gibberellins and can thus be used to reduce unwanted shoot elongation (Singh, 2004). In ornamental horticulture, the plant growth retardants are utilized to produce compact and sturdy plants commercially. This practice allows in obtaining a better ratio between vegetative growth and flower production. Growth retardants are also used to enhance the green color of the foliage, strengthen the flower stems and stimulate the flowering and promote resistance against environmental stresses (Kahar, 2008). Other benefits of using these PGRs in plant production include improved plant appearance by maintaining plant size and shape in proportion with the growing area. Growth retardants have increased the compactness and hardiness of the plants so that their handling and maintenance become easy. The typical growth retardants are B-Nine, Cycocel, A-Rest, Bonzi, Maleic Hydrazide, Tri Iodo Benzoic Acid and Sumagic.

Strikingly elegant flower heads rise from banana like clumps of oval leaves which are sometimes rather slender and extremely large in some varieties. Most of species of heliconia have more height often with extensive rhizomatus growth. Because of extensive growth habit, it requires more area for growing which is commercially very difficult to grow for production. Further, the plant requires more days for flower production. Certain plant

growth retardants like CCC, MII, TIBA, Paclobutrazol, etc. have known to reduce the plant height and increase production in plants like African marigold (Sunitha, 2006), Chrysanthemum (Navale *et al.*, 2010) and Salvia (Kumar *et al.*, 2012).

However, research with regard for producing profuse flowering in heliconia by using plant growth retardant has not been worked out yet. Hence, this experiment was conducted to study the effect of plant growth retardants on the growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. 'Red Torch' under 50 per cent shade net condition with the following objectives:

- I. To study the effect of plant growth retardants on vegetative growth of heliconia var. 'Red Torch'.
- II. To evaluate the effect of plant growth retardants on flowering and yield of heliconia var. 'Red Torch'.
- III. To find out economics of different treatments.



REVIEW
OF
LITERATURE

II. REVIEW OF LITERATURE

The heliconia is an important high value flower crop. The commercial flower production of heliconia requires more days. But with the use of plant growth retardants, the vegetative growth can be suppressed and early flowering and more yield can be taken.

A number of reports are available to support the above mentioned facts in various flower crops. The prominent findings of some of the reports pertaining to growth and yield of flower crops as influenced by different growth regulation practices have been reviewed and presented here as under. Since, no research work has been done in heliconia but the research reports related to other ornamental flower crops have been included in this chapter.

2.1 Cycocel (CCC)

Chlormequat chloride (commonly known as cycocel, citadel or chlormequat E-Pro) is very popular plant growth retardant. Cycocel, contain a quaternary ammonium group which have been developed to target the terpene synthases in stage-1 of GA bio-synthesis, of which *ent*-copalyl diphosphate synthase (CPS) is an example. It inhibits GA production early in the process by blocking the synthesis of the GA-precursor *ent*-copalyl diphosphate (Taiz and Zeiger, 2003).

Conover *et al.* (1968) reported that 75-100 % flowering was increased with the application of 0.25 % cycocel spray in *Gardenia jasminoides* 'Veitchii' and 'Glazeri'. Further,

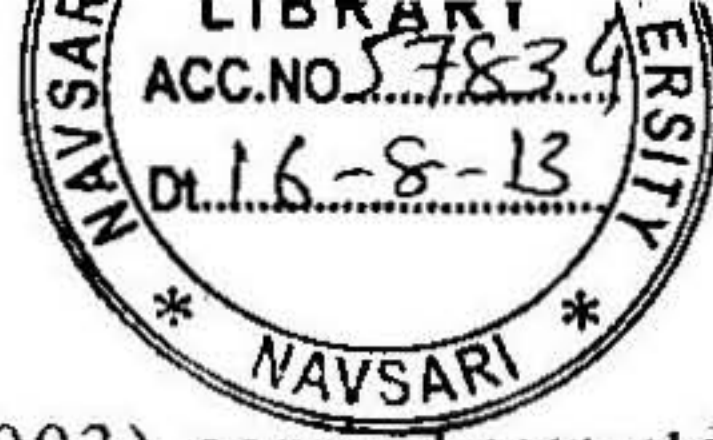
Shanmugam and Muthuswamy (1974) reported the marked suppression of plant growth at all concentrations of CCC (500, 1000 and 2000 ppm) as compared to control in *Chrysanthemum indicum* L. cv. White. Bhattacharjee (1989) reported that the largest number of shoots (123.75 cm), flower bud length (1.98 cm) and flower yield per plant per year (3696 g) were obtained with the application of cycocel @ 1000 ppm in *Jasminum grandiflorum* L.

Gowda (1985) reported that application of CCC @ 1000 ppm increased the number of branches, nodes, leaves, number of flowers per plant, flower yield and decreased the number of days to 50 per cent flowering in China aster. In contrast to this, a reduction in intermodal length was observed when the concentrations were increased. Further, Gowda and Jayanthi (1991) reported that foliar spray of cycocel (200 ppm) successfully reduced plant height, remaining all concentrations (1000, 1500 and 2000 ppm) increased the number of branches at pre blooming stage (26.20 and 26.80 per plant) and post blooming stage (53.40 and 52.90 per plant) in first and second season, respectively in African marigold.

Foley and Keever (1991) observed that when plants were treated with the foliar application of cycocel @ 3500 ppm, recorded minimum plant height, minimum days to flower (140 days) and higher flower bud number (12.00) in dianthus. Further, Foley and Keever (1992) also recorded that one time and two times foliar application of 3500 ppm cycocel was most effective in suppressing shoot elongation. Maximum suppression of plant

height (about 70 % less than the control plants) occurred at 8th week. They also found the darker green foliage with cycocel application as compared to control in Pink Polka-Dot plant. While working with China aster cv. 'Powder Puff Mixed', it was observed that higher number of leaves and branches were obtained with 1500 ppm cycocel treatment and also resulted in increased number of flowers. CCC @ 1500 ppm caused significant reduction in plant height when applied at 95 and 125 days after sowing (Aswath *et al.*, 1994).

Latimer and Baden (1994) conducted experiment on persistent effect of plant growth regulators on landscape performance of seed geraniums. Foliar spray of 1500 ppm cycocel was applied to seed of geraniums to determine effects on growth in the greenhouse and the subsequent performance of treated plants in landscape than found minimum stem length (8.1 and 7.1 cm) and maximum number of branches per plant (1.6 and 1.8) in 'Ringo White' and 'Ringo Rose' geranium, respectively. Further, Khan and Tewari (2003) investigated the effect of growth regulators on growth and flowering of dahlia and revealed that plant height and leaf area was significantly reduced with increasing concentrations of cycocel. Moreover, maximum reduction of plant height, leaf area and the period of full bloom were observed in 6000 ppm cycocel treatment, whereas cycocel at 4000 ppm significantly increased number of branches, number of leaves per plant, flower diameter, shelf life on plant and number of flowers per plant compared to the rest of treatments in dahlia.



Khandelwal *et al.* (2003) ~~carried out~~ the experiment on effect of growth retardant on African marigold cv. 'Pusa Narangi Gaiinda' and recorded minimum plant height (51.77 cm), maximum branches per plant (74.46), duration of flowering (54.93 days), flower longevity (24.46 days) and number of flowers per plant (67.01) with application of cycocel @ 3000 ppm. They also found that the maximum flower diameter and weight of flower when plants were sprayed with the CCC @ 1000 ppm as compared to control.

Warner and Erwin (2003) carried out the experiment on effect of plant growth retardants on stem elongation of hibiscus species and observed that chlormequat chloride @ 2000 mg/l significantly reduced stem length (87, 42 and 52 %) as compared to untreated plants in all Hibiscus species *viz.* *H. coccineus*, *H. radiatus* and *H. trionum*, respectively.

Joshi and Reddy (2006) reported that application of CCC @ 2000 ppm effectively reduce plant height (35.74 cm), increase number of leaves per plant (10.66) and number of flowers per plant (55.2) as compared to the control and other treatments in China aster. Mishra and Pandey (2006) conducted an experiment on African marigold cv. 'Pusa Narangi Gaiinda' and observed minimum plant height (35.9cm), maximum flowers per plant (34.7) and branches (16.2) with application of treatment CCC @ 1000 ppm + pinching as compared to control. They also recorded that treatment of CCC @ 250 ppm + no pinching significantly increased flower size (6.4 cm) as compared to control. Application of

cycocel @ 500 ppm in jasmine was beneficial for the vegetative growth and to minimize days to flowering as well as increase the flower production (Sridhar, 2006).

Further, Sunitha (2006) conducted an experiment on African marigold cv. 'Double Orange'. They reported that the application of CCC @ 1000 ppm produced minimum plant height with maximum number of branches and flower yield per plant than control. Similar way Abbas *et al.* (2007) investigated the effect of growth retardants to break apical dominance in *Rosa damascena*. At applied cycocel at different concentrations as a foliar spray and observed superiority on different morphological and floral characteristics of *Rosa damascena*. Minimum plant height (6.47 cm), least shoot length (6.23 cm), maximum flowers size (38.52 cm²) and number of leaves (11.50) were observed with the spray of cycocel @ 1000 ppm which attained significant superiority over rest of treatments.

Lodeta *et al.* (2010) found that application of cycocel @ 1500 and 3000 ppm after the third spray caused around 20 % shorter plants, decreased the leaf area (4 -10 %) and bract area (around 40 %) as compared to control. Whereas chlorophyll a, chlorophyll b and carotenoid in leaves were enhanced as compared to control in poinsettia cv. 'Christmas Feelings'. Flower stem height is one of the important factor for potted plants, which was influenced by cycocel. The least flower stem height (29.93 cm) was obtained by using 1500 mg/l cycocel in rose cv. 'Poison' (Hashemabadi and Zarchini, 2010).

Bhat *et al.* (2011) investigated the effect of foliar spray of different growth retardants (cycocel and B9) on growth and flowering of *Erysimum marshallii*. The plants were sprayed with three concentrations of growth retardants *viz.* 500, 1000 and 1500 mg/l which was prepared in 0.1 % Tween 80 solution. Minimum plant height, leaf area and maximum flower diameter were observed with the application of cycocel at lower concentration (500 mg/l), while maximum number of laterals and flowers per plant were observed with the higher concentration of cycocel *i.e.* 1500 mg/l as compared to control. Similar way, Sharifuzzaman *et al.* (2011) also found the maximum flower size and lowest stalk length with cycocel regardless different concentration in chrysanthemum. Furthermore, Wazir (2011) reported that cycocel @ 1500 ppm with drench and spray application in potted alstromeria gave maximum number of cymes per inflorescence and increased duration of flowering with good pot presentability.

Hashemabadi *et al.* (2012) carried out an experiment to study the effect of spray application of two plant growth retardants (cycocel and daminozide) on the growth, flowering and amount of essential oils of *Calendula officinalis*. Combination of cycocel (0, 500, 1000 and 1500 mg/l) and daminozide (0, 1500, 3000 and 4500 mg/l) was used three times. They found that CCC and B9 had significant effect on the amount of essential oils per 100g dried flower and plant height ($p \leq 0.01$). Also, interaction effects of CCC and B9 were significant on plant height, the number of flowers per plant, number of leaves per plant, flower dry weight and the amount of essential oil per 100 g dried flower. The lowest plant

height (30.67 cm), the largest number of flowers per plant (3.33) and the highest number of leaves (6.67) were observed in 500 mg/l CCC + 4500 mg/l B9, 500 mg/l CCC + 1500 mg/l B9, 500 mg/l CCC + 1500 mg/l B9 and 1500 mg/l CCC + 1500 mg/l B9, respectively.

Kumar *et al.* (2012) investigated the effect of growth retardants on growth of *Salvia* and found maximum leaves per plant (70.22), number of branches per plant (11.89) and diameter of the stem (0.86 cm) with the application of cycocel @ 1000 ppm.

2.2 Maleic Hydrazide (MH)

Maleic hydrazide is one of the important growth retardant. Its active ingredient is 1,2, dihydro-3,6 pyridazinedion.

Dutta *et al.* (1993) carried out the research on regulation of flowering by growth regulation in chrysanthemum cv. 'Co-1', which were treated with foliar spray of maleic hydrazide. They found that MH @ 250 ppm was effective to obtain early flowering, maximum flowering duration, size and length of flowers as compared to the control and other concentration of maleic hydrazide. Kumar and Kumar (2004) studied the effect of maleic hydrazide on growth and flowering in balsam (*Impatiens balsamina* L.). The MH treatments were given as foliar spray @ 0, 50, 100, 250, 400, 500, and 700 ppm after one month of planting. Application of MH @ 700 ppm decreasing plant height (63.93 cm) and MH @ 250 ppm increasing number of flowers per plant (18.20) with maximum duration of flowering (78.06 days) in the balsam. Among the various treatments, MH @ 1500 ppm resulted

in more number of leaves, lateral branches, highest number of flowering spikes and yield per plant in triploid crossandra (*Crossandra undalaefolia*) (Venkatesan *et al.*, 2004).

Baskaran and Misra (2007) observed that the application of MH @ 500 ppm in gladiolus was found very effective to reduce the plant height, days to 50% sprouting and maximized the shoots per corm, leaves per plant and leaf area. Additionally, it was also very effective to increase the flower quality and production. Application of MH @ 1500 ppm effectively reduced plant height (137.16 cm), increase the number of shoots (55.10), leaves per plant (163.87) in *Nerium odorum* (Anburani and Ananth, 2008). Further, Kashid *et al.* (2010) observed minimum plant height as well as maximum flower yield and oil content in sunflower when it was treated with MH @ 300 ppm. MH @ 1250 mg/l recorded the maximum reduction in plant height with maximum number of branches, plant spread, shelf life and vase life of flowers, whereas it was also found beneficial for delaying and increasing the duration of flowering. However, in case of flower yield per plant and per hectare, the lower concentration of MH at 750 mg/l was found significantly superior as compared to other treatments (Navale *et al.*, 2010). When chrysanthemum treated with MH @ 250 ppm, it took minimum days to flowering, maximum flower size and stalk length as compared to the MH @ 500 and 750 ppm (Sharifuzzman *et al.*, 2011).

2.3 Tri Iodo Benzoic Acid (TIBA)

2,3,5-triiodobenzoic acid is commonly known as TIBA which is one of the traditional PGR used in the floriculture. It is well known for many years as an inhibitor of the basipetal polar auxin transport in plants. The presence of TIBA as an inhibitor of polar auxin transport, would affect a suitable hormonal balance in favor of the earlier flowering of partially cooled tulip bulbs (Saniewski *et al.*, 2011).

Shanmugam and Muthuswamy (1974) reported that all the concentrations of TIBA (100, 200, 400 ppm) induced early flowering, increase flower size and increase duration of flowering also as compared to control in *Chrysanthemum indicum* L. cv. 'White'.

2.4 Paclobutrazol

Keever and Foster (1989) reported that the spray of paclobutrazol at 100 and 150 ppm controlled bypass shoot development and increased flower number of azalea cv. 'Alaska' compared to the control, while minimally affecting forcing time and bloom size. Sprays of 150 and 200 ppm suppressed bypass shoot development and increased flower number of azalea cv. 'Prize' compared to the control without affecting bloom size. Paclobutrazol was more effective than B-Nine (daminozide) in suppressing bypass shoot development and enhancing flowering. Forcing time decreased and bloom size increased for paclobutrazol-treated plants of both cultivars compared to daminozide-treated plants.

Foley and Keever (1991) carried out the research on annual carnation (*Dianthus caryophyllus*) and garden pink (*Dianthus chinensis*), which were treated with foliar sprays of bonzi (paclobutrazol) and pruned to suppress shoot elongation or promote axillary shoot development. They found that bonzi @ 100 or 200 ppm was effective in suppressing shoot elongation of annual carnation over a 14 weeks period and garden pink over an 8 weeks period without increasing days to flower of either species. The combination of pruning and bonzi inhibited shoot elongation of both species compared to pruning alone. Moreover, various spray rates of paclobutrazol (20, 40 and 90 ppm) were applied to three bedding plant species to determine effects on growth in the greenhouse and landscape. Seedlings of *Zinnia elegans* 'Peter Pan Scarlet' responded to the all concentration of paclobutrazol. However, zinnias treated with paclobutrazol exhibited reductions in plant height 5 and 6 weeks after transplanting. Stem elongation of *Impatiens wallerana* 'Accent Red' seedlings were moderately controlled by 20 ppm in the concentration.

Cid and Caballero (1993) reported that application of paclobutrazol by drenching were the most suitable treatments in *Nauplis sericeus* and *Salvia canariensis*. Drenching of paclobutrazol significantly reduced plant height than spray. Further, Latimer and Baden (1994) found that application of paclobutrazol in two cultivar of geranium with different concentrations reduced stem length and shoot dry weight as well as time required for flowering, while branching was increased relatively to the untreated plants. However, only 7 ppm

paclobutrazol reduced plant height and width of 'Ringo White' and 'Ringo Rose' at 6 weeks after planting.

Terri and Millie (2000) observed that drenching of paclobutrazol @ 4.0 mg/l in scalvola plant cv. 'New Wonder' reduced plant width and flower stem length without affecting flower stem number or time to flowering. Flower number per stem and stem length were increased, resulting in attractive, compact cluster of flowers. Paclobutrazol @ 0.5 mg per plant was most effective treatment to reduce plant height by 73.1 % in *Richardia tingitana* (Banon *et al.*, 2003). Furthermore, Warner and Erwin (2003) carried out the research on effect of plant growth retardants on stem elongation of hibiscus species and observed that paclobutrazol (20 and 40 ppm) significantly inhibit stem elongation as compared to untreated plants in all Hibiscus species viz. *H. coccineus*, *H. radiatus* and *H. trionum*.

Delaune (2005) found that the application of paclobutrazol as a spray (100 and 200 ppm) and drench (0.5 and 1.0 ppm) gave good response to flowering in different species of clerodendrum grown as flowering pot plants. All concentrations of paclobutrazol (0.5, 0.75 and 1.0 mg per pot) significantly reduced plant height and side branches without affecting flower diameter. It delayed production cycle and causing phytotoxicity (Pinto *et al.*, 2005). In similar way, Sullhan *et al.* (2005) reported that the plant height was effectively reduced by 20 ppm paclobutrazol in geranium cv. Laction Pink and this treatment produced the highest number of shoots per plant and maximum number of inflorescences

per plant with the combination of inoculated *Azotobacter* and half dose of nitrogen. The application of 200 ppm paclobutrazol through soil drench proved to be the most effective for reducing the plant height where the highest numbers of branches per plant and flower production per plant were observed with paclobutrazol @ 25 ppm in China aster (Mishra and Mishra, 2006).

Fatma *et al.* (2007) reported that foliar spray of paclobutrazol @ 500 ppm concentration increased plant height of bougainvillea where as plants received 250 ppm decreased plant height as well as number of branches and leaves per plant, stem diameter, fresh and dry weight of stem, leaves and roots were increased significantly by 250 and 500 ppm concentration and it also significantly increased number of flowers per plant as well as fresh and dry weight of the flowers as compared to control. An experiment carried out to study the effect of paclobutrazol with different concentrations (0.5, 1 and 2 ppm) supplied to the recycling nutrient solution in an ebb and flow system on the growth and flowering of kalanchoe cv. Gold Strike. All the applied concentrations, plant size decreased as compared to the control. However, the number of florets increased in the treated plants. Results indicated that the subirrigation application of cultar @ lower concentration could be used as an effective mean for suppressing stem growth (Hwang *et al.*, 2008).

Francescangeli (2009) studied the effect of paclobutrazol in irish cv. 'Casablanka' and 'Professor Blauw'. Bulbs were dipped in paclobutrazol @ 0, 10, 20, 30, 40, 50, 60, 70

and 80 mg/l for 24 hours. A concentration of 20 mg/l was effective to achieve harmonious plants and reduce the plant height (33 cm) as compared to the control.

Dhiman (2011) conducted an experiment to study the influence of pre-plant bulb dipping in paclobutrazol solutions in LA hybrid. 'Cilesta' LA hybrid bulbs were dipped in solutions of paclobutrazol @ 0, 50, 100, 150 and 200 mg/l for 10 min preceding planting. By increasing cultural dose progressively reduced the height of 'Cilesta' hybrid by between 10 % (84.65 cm; 50 mg/l) and 36 % (60.26 cm; 200 mg/l) compared to control plants (94.55cm). He also observed that dipping LA hybrid bulbs of liliium in paclobutrazol solutions can be an effective strategy for reducing stem elongation without negatively impacting days to flower or flower bud length for commercially grown LA hybrids.



MATERIAL

&

METHODS

III. MATERIAL AND METHODS

The investigation entitled "Effect of plant growth retardants on the growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 per cent shade net condition" was carried out during the year 2012-2013. During the course of investigation, the materials used and the techniques adopted are presented in this chapter.

3.1 General

3.1.1 Experimental site

The experiment was carried out under 50 per cent shade net house at Block-D, Plot No.-13, Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari.

Navsari is situated at 20° - 95' North latitude and 75°-95' East longitude at an altitude of 10 m above mean sea level. The experimental site i.e., Floriculture Research Farm is located three kilometres away in the west from Navsari and 12 kilometres away in the east from Arabian seashore, the historical place 'Dandi'.

3.1.2 Climatic conditions

The climate of South Gujarat where the Floriculture Research Farm of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari is situated is typically

tropical characterized by fairly hot summer, moderately cold winter and warm humid monsoon.

Generally, monsoon in this region commences in the second week of June and retreats by the end of September. Pre-monsoon rains in the last week of May or in the first week of June are not uncommon. Most of the precipitation is received from South-West monsoon, concentrating in the months of July and August. Average annual rainfall of this region is about 1431 mm.

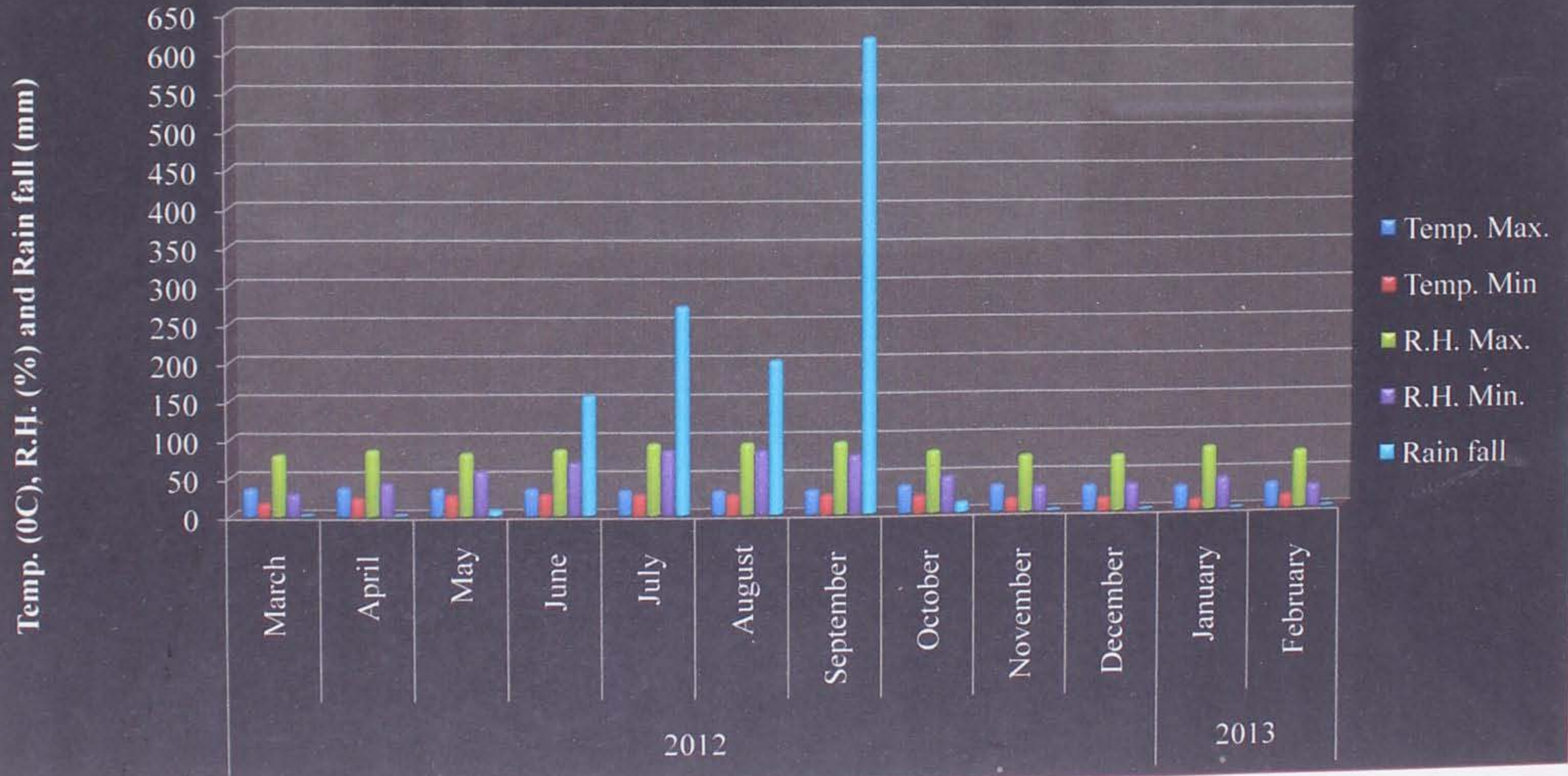
The winter season sets usually towards the end of October. The lowest temperature of the season is recorded either in December or January (10 to 23.8°C) and hence, these two months are the coldest months of the season. From February onwards, the temperature starts rising and reaches the maximum in the month of May. Thus, May is the hottest month of the summer season.

The meteorological data on maximum and minimum temperatures, relative humidity, sunshine hours and rainfall during the course of experiment recorded from the Meteorological Observatory, Navsari Agricultural University, Navsari have been given in Fig. 3.1.

3.1.3 Soil characteristics

The soil type of Navsari campus is black cotton soil, which is very rich in organic matter and potash, having good water holding capacity with fairly well drainage and thus reasonably suitable for cultivation of heliconia.

Fig-3.1 : Meteorological parameters recorded during the growth and development of heliconia var. Red Torch (monthly mean)



The physical and chemical properties of soil of Block-D, Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari are presented in Table-3.1 and 3.2.

Table 3.1 Physical properties of soil

| Sr. No. | Particulars | Value in per cent (0-30 cm depth) |
|---------|----------------|-----------------------------------|
| 1. | Coarse sand | 0.69% |
| 2. | Fine sand | 9.17% |
| 3. | Silt | 24.94% |
| 4. | Clay | 65.20% |
| 5. | Textural class | Clayey |

Table 3.2 Chemical properties of the soil

| Sr. No. | Particulars | Value | Method employed |
|---------|---|--------|--|
| 1. | pH | 7.7 | Blackman's pH meter (Jackson, 1967) |
| 2. | Total N (%) | 0.052 | Modified Kjeldahl's method (Jackson, 1967) |
| 3. | Available Nitrogen (kg ha ⁻¹) | 160.00 | Alkaline permanganate method (Jackson, 1967) |
| 4. | Available Phosphorus (kg ha ⁻¹) | 40.02 | Olsen <i>et al.</i> (1954) |
| 5. | Available Potash (kg ha ⁻¹) | 384.50 | Flame photometer (Jackson, 1967) |

3.2 Experimental details:

1. **Site** : 50 per cent Shade Net House
Block-D, Plot No.-13
Floriculture Research Farm
ASPEE College of Hort. & Fort.
N.A.U., Navsari - 396 450
- 2 **Year** : March 2012 - Feb 2013
- 3 **Crop** : *Heliconia (Heliconia psittacorum)*
- 4 **Variety** : Red Torch
- 5 **Experimental design** : Randomized Block Design
- 6 **No. of replications** : 03
- 7 **Number of treatments** : 09
- 8 **Planting distance** : 1 m x 0.8 m
- 9 **Total number of plots** : 27
- 10 **Plot size** : 3.2 m x 2 m
- 11 **No. of plants in plot** : 08
- 12 **Total experimental area** : 18 m x 12 m
- 13 **Treatment details** :

The treatment details regarding retardants and their different concentrations as under.

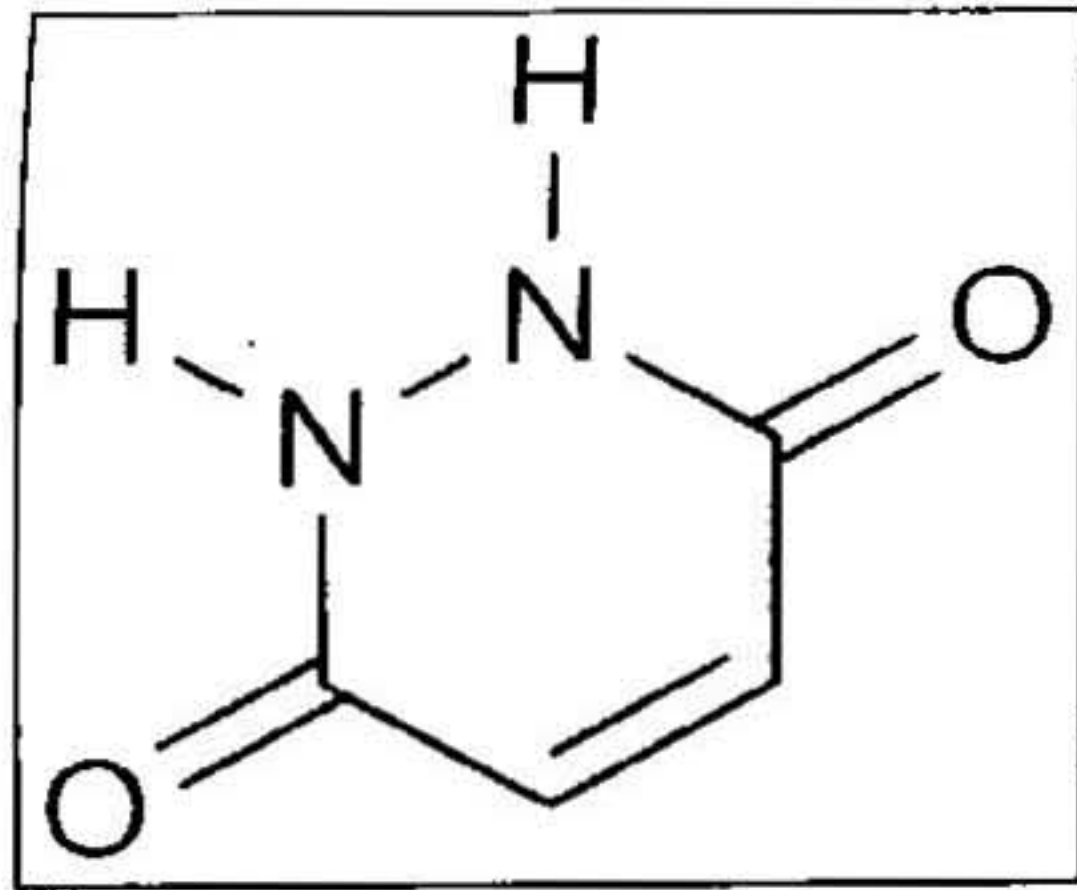
- T₁ : Cycocel @ 100 ppm
- T₂ : Cycocel @ 200 ppm
- T₃ : MH @ 25 ppm
- T₄ : MH @ 50 ppm
- T₅ : TIBA @ 15 ppm
- T₆ : TIBA @ 30 ppm
- T₇ : Paclobutrazol @ 150 ppm
- T₈ : Paclobutrazol @ 300 ppm
- T₉ : Control

3.3 Source of planting material

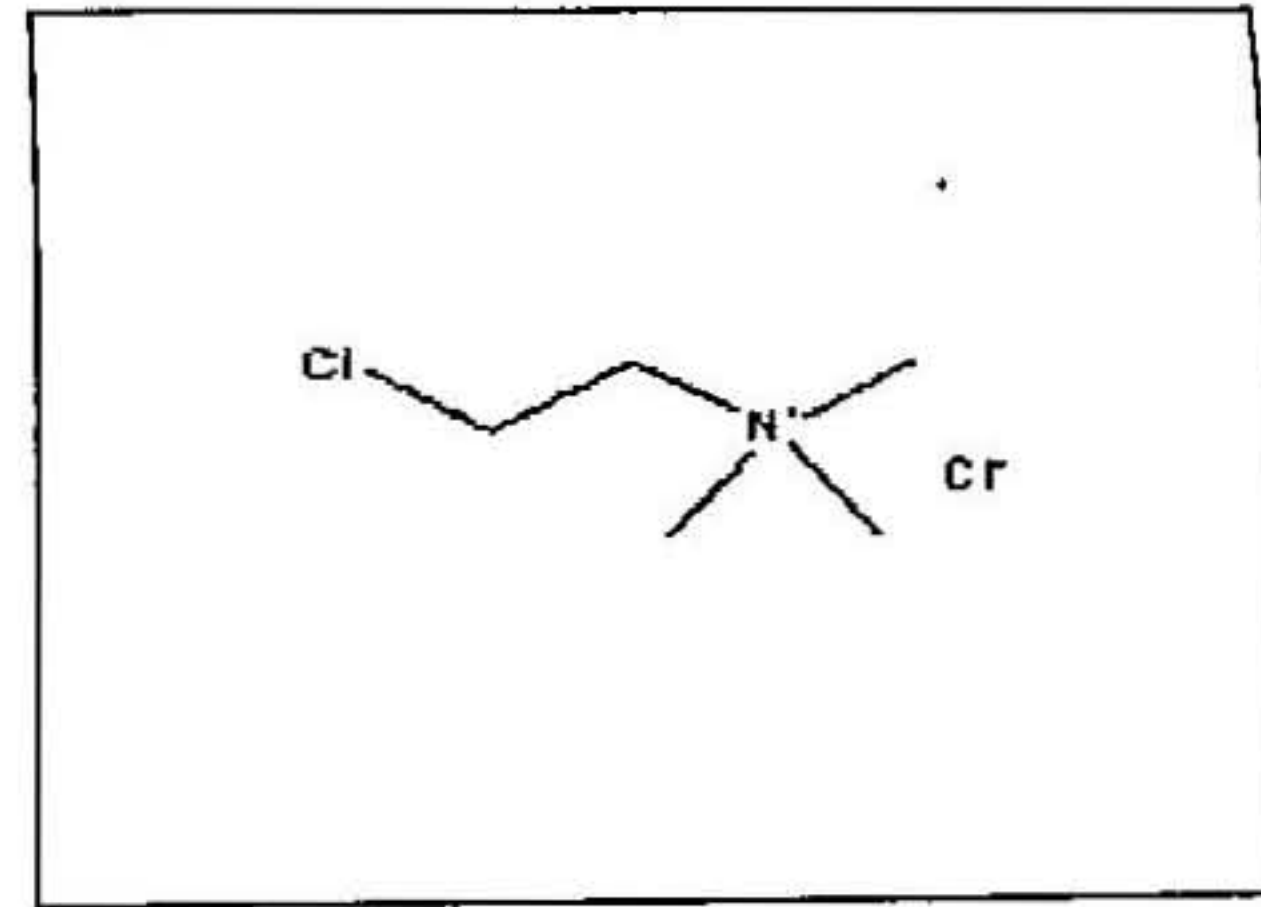
Healthy, homogenous sprouted rhizomes of heliconia having 12-15 cm height of var. 'Red Torch', free from diseases were procured from Floriculture Research Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari.

3.4 Preparation of experimental plots

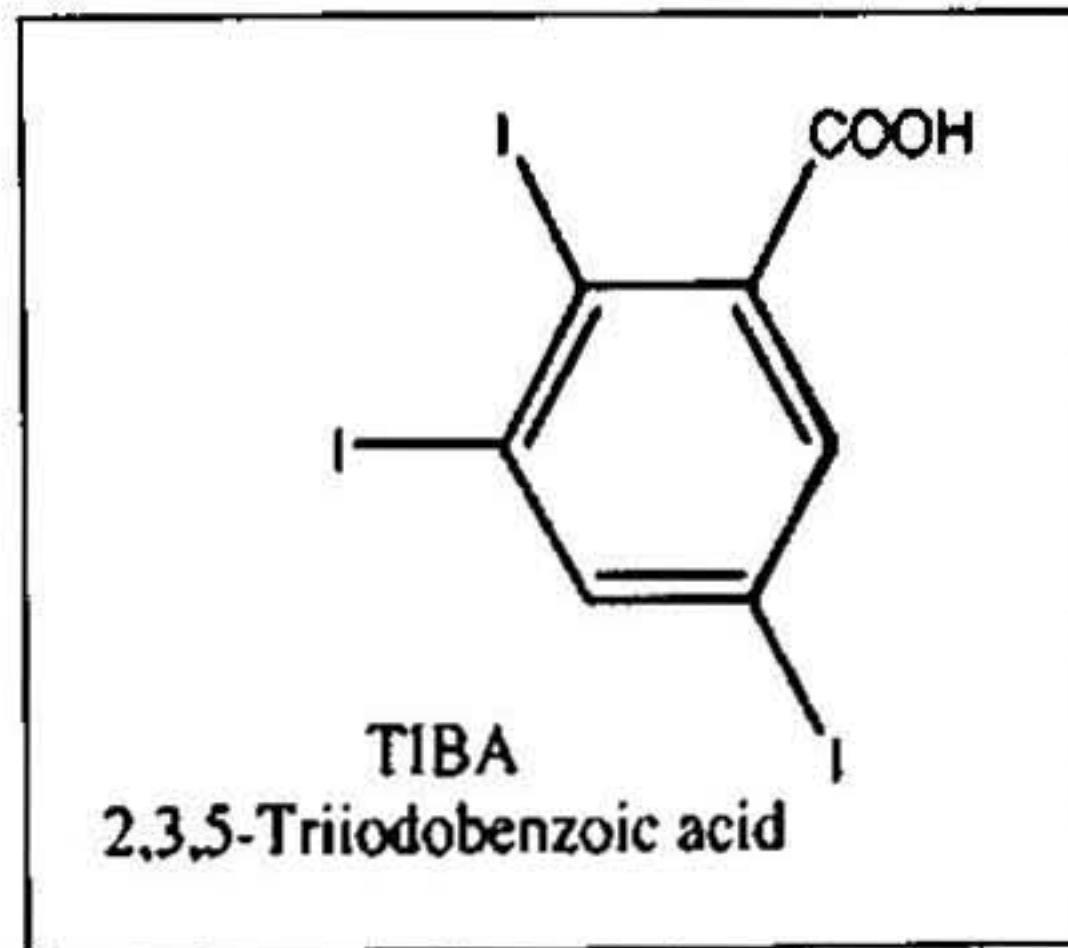
The land was brought to a fine tilth by ploughing and then worked with cultivator. The pebbles of various sizes, roots of weed plants, etc. were removed. Thereafter, the layout of experiment was done with the raised beds of 60 cm width, 20 cm height and 40 cm path. The experimental field was surrounded by heliconia plants to provide border.



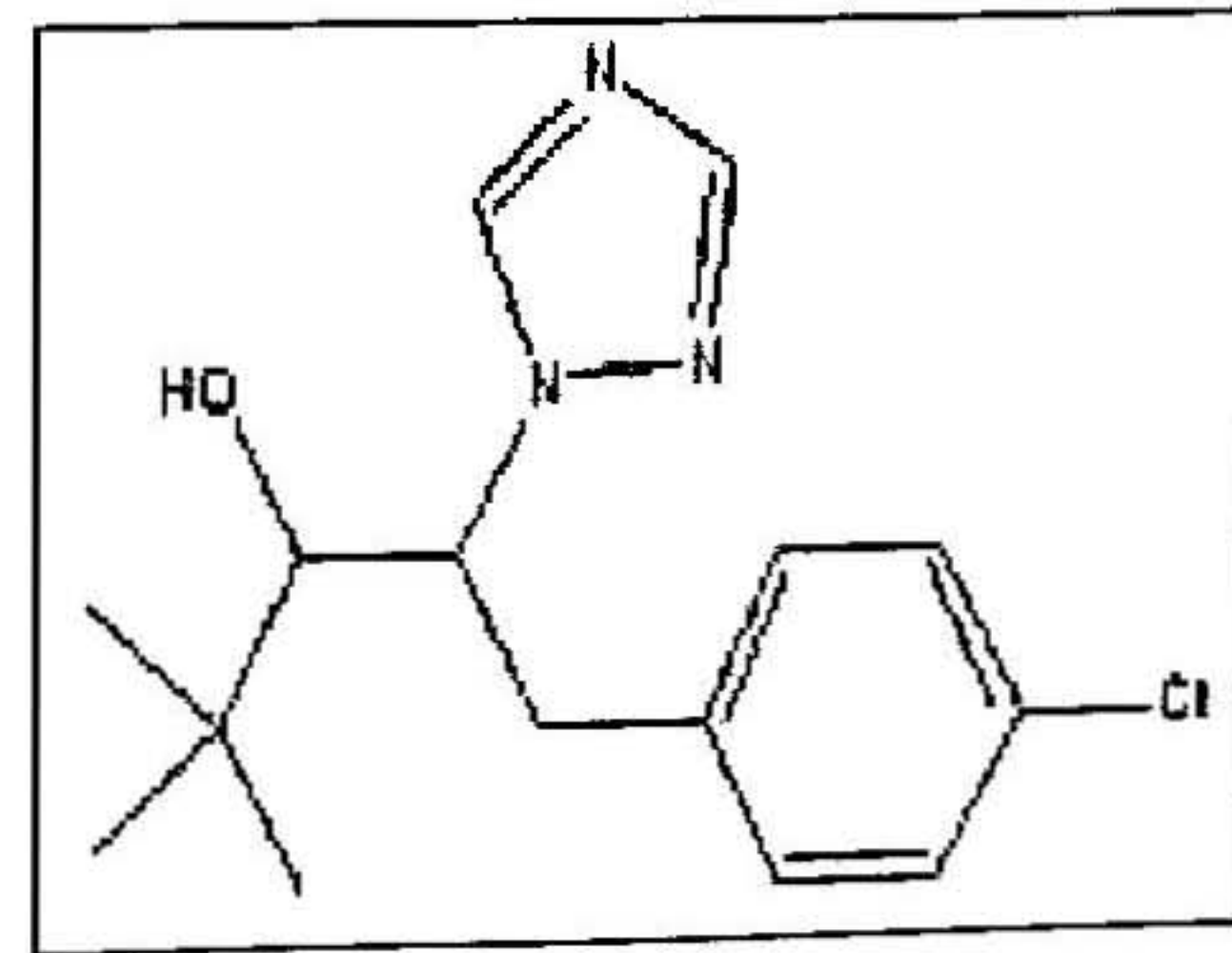
Maleic hydrazide



Cycocel



2,3,5 – Triiodobenzoic acid



Paclobutrazol

Fig. 3.2 : Structural formula of various plant growth retardants.

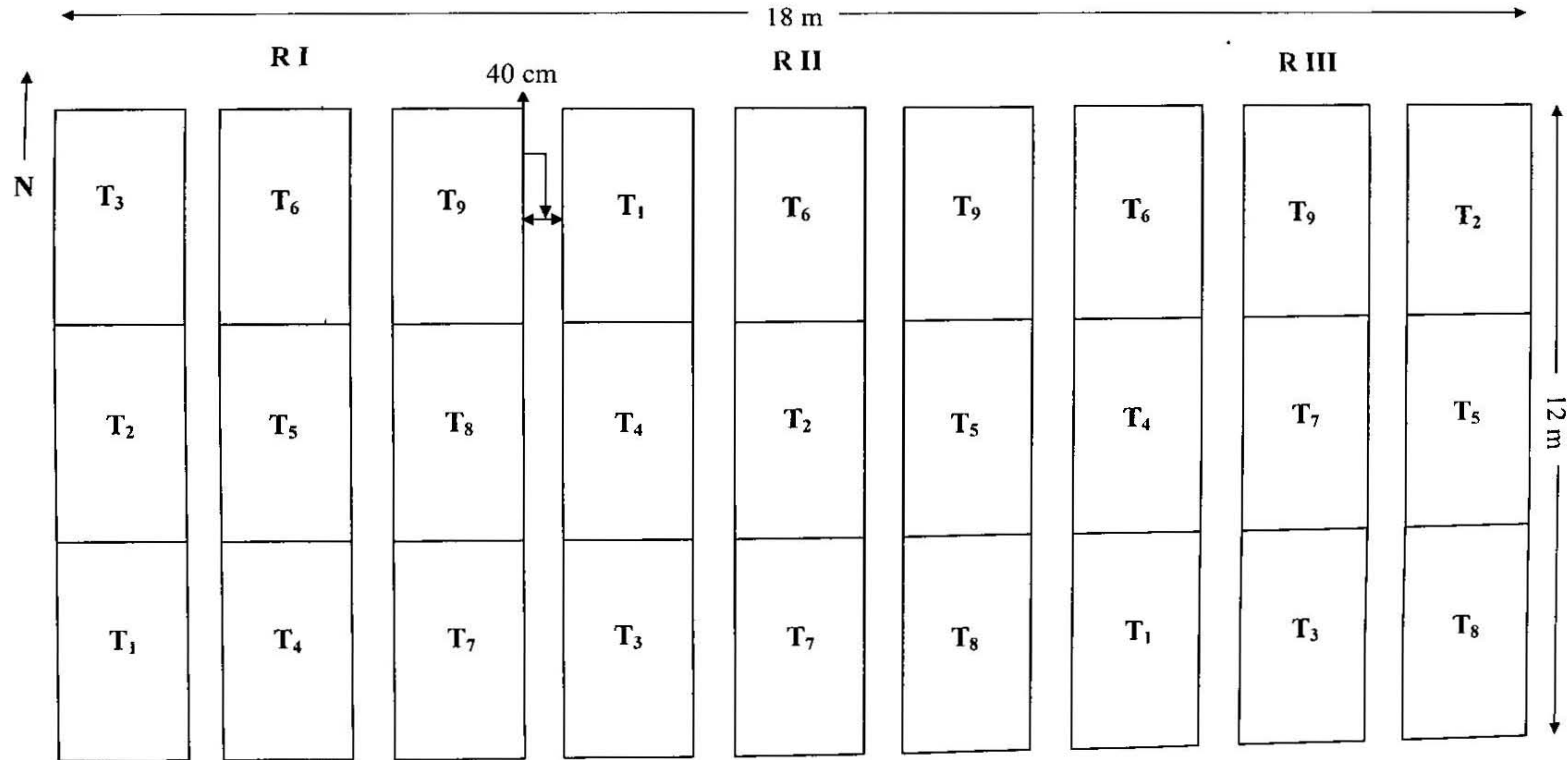
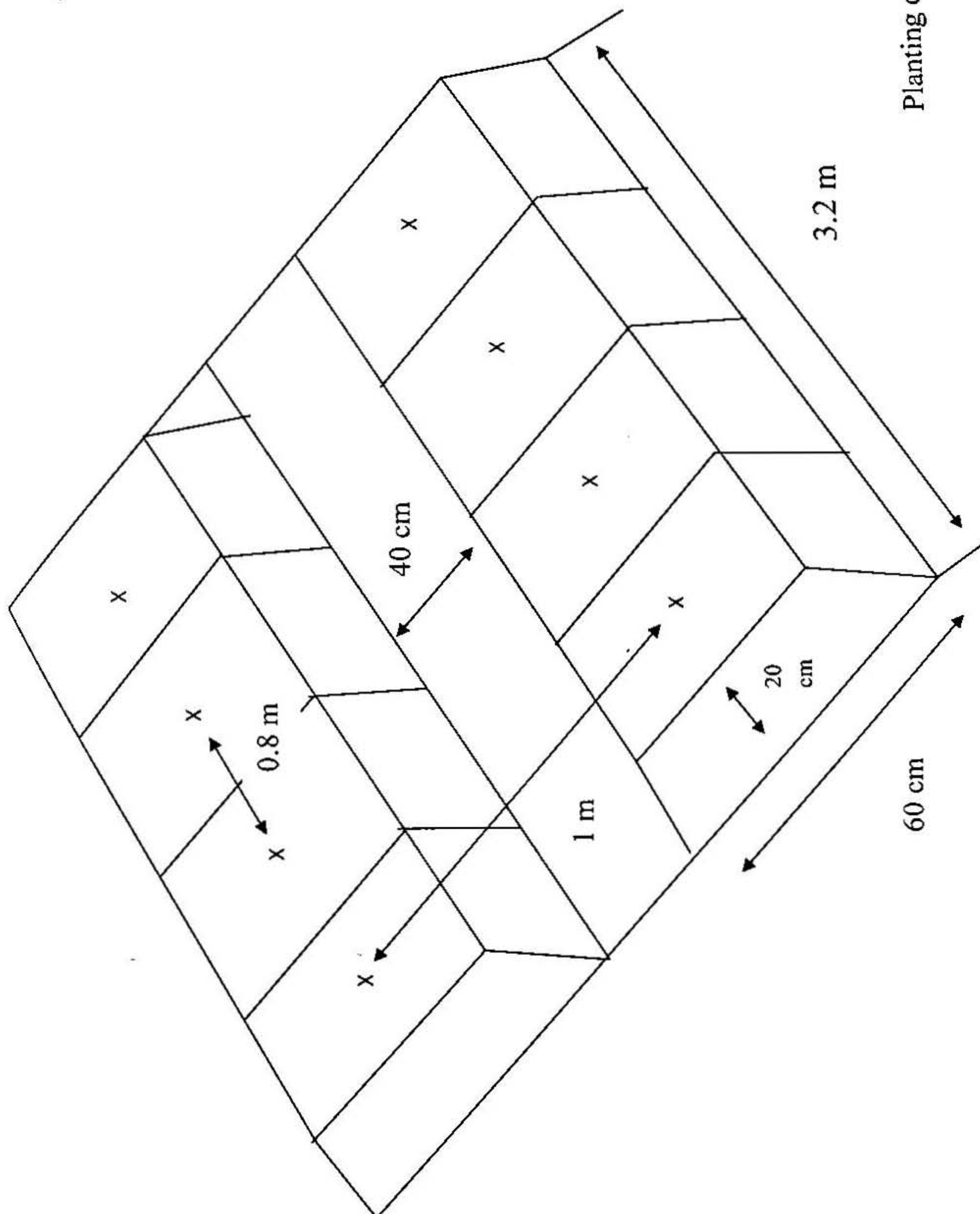


Fig. 3.3 : General layout of experimental field.



Planting distance : 1 m x 0.8 m

Fig 3.1 : Layout plan of experimental plot.



Plate-I : General view of shade net house



Plate - II : General view of experiment

Then the plots of 3.2 m x 2.0 m were made as per experimental layout so each plot accommodates 8 plants with spacing of 1.0 m row to row and 0.8 m plant to plant (Fig.3.2 and 3.3).

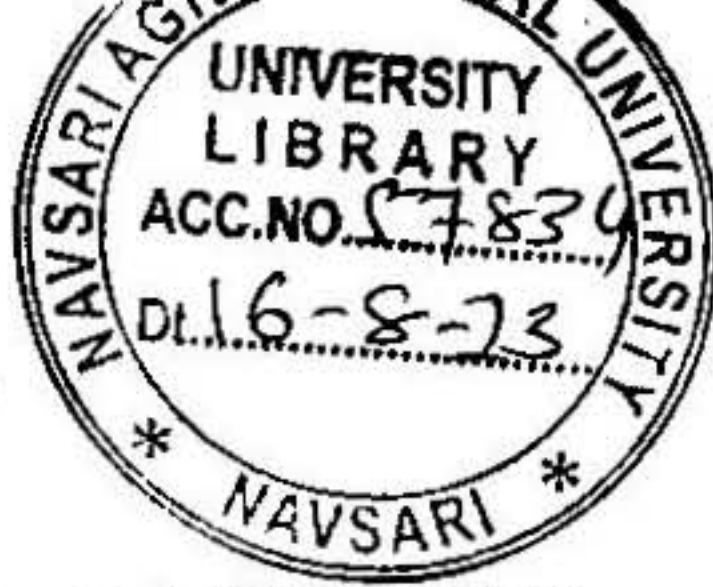
3.5 · Application of manure and fertilizer

Uniform basal dose of vermicompost @ 4 kg/m² was applied in two equal split doses. First dose was applied at the time of planting as basal dose and remaining half dose was applied after 3 months as top dressing.

In addition to vermicompost, application of 15 g N (urea), 20 g P (SSP) and 10 g K (MOP) per m² were also applied to each plot at the time of planting. These fertilizers thoroughly mixed in the soil than pits were filled. Second dose of N i.e. 15 g per m² was given after three months of planting by preparing circular shallow ring at about 10 cm away from the base of each plant with a depth of 3-5 cm.

3.6 Planting

The healthy, uniform sized sprouted rhizomes of heliconia var. Red Torch were planted at a spacing of 1 x 0.8 m under 50 per cent shade net house by digging pits at 10 to 15 cm depth on raised beds. Then the beds were irrigated by drip thoroughly to maintain the optimum soil moisture condition. The rhizomes were soaked in 0.2 % bavistin solution for 10-15 minute than dried for an hour under shade prior to planting.



3.7 Irrigation

A light irrigation immediately after planting of suckers under the net house was given for proper establishment. The plots were given uniform and regular irrigation by drip system with the discharge of 8 lph and 90 cm of distance between two drippers at an alternate day, except rainy season.

3.8 Preparation of stock solution of growth retardants

3.8.1 Cycocel (CCC) Solution

100 ppm and 200 ppm of cycocel solutions were prepared by adding @ 4.8 and 9.6 ml cycocel (50 % v/v), respectively in 24 litres of distilled water with the help of pipette.

3.8.2 MH Solution

For preparation of 25 ppm and 50 ppm MH solutions, maleic hydrazide (98 % w/w) @ 0.6 and 1.2 g, respectively were weighed accurately on electronic balance and dissolved in small quantity of 0.1 N NaOH then made final volume of 24 litres by adding distilled water.

3.8.3 TIBA Solution

For preparation of 15 and 30 ppm solution, TIBA (97 % w/w) was weighed @ 0.36 and 0.72 g accurately on electronic weighing balance and then dissolved in small quantity of DMSO + 0.1N NaOH and make final volume of 24 litres by adding distilled water.

3.8.4 Paclobutrazol Solution

Paclobutrazol @ 150 and 300 ppm solutions were prepared by adding 14.4 and 28.8 ml paclobutrazol (25% w/v), respectively in 24 litres of distilled water with the help of pipette.

3.9 Time and method of treatment application

First drenching of growth retardants was done at 30 days after planting. A second and third drenching of growth retardants was done at 10 days interval after first drenching.

3.10 Collection of the data

Five plants were selected randomly from a plot and tagged for recording the observations from each treatment and the average was worked out later.

3.11 Observations recorded

3.11.1 Vegetative parameters

The vegetative parameters of heliconia plant were recorded at the interval of 3, 6, 9 and 12 months after planting (MAP), except leaf area which was recorded at 12 MAP.

3.11.1.1 Plant height (cm)

Plant height was measured from the base of the clump *i.e.* above the growing media to the top of the plant leaf of tallest sucker or plant with the help of standard scale from tagged clump and average was worked out and expressed into centimetre.

3.11.1.2 Number of leaves

Number of leaves was counted from the tallest plant of clump from tagged plants then average number of leaves per plant was worked out.

3.11.1.3 Number of suckers per clumps

Total number of suckers was counted from tagged plant (clump) and then average was worked out.

3.11.1.4 Leaf area (cm²)

For measuring leaf area, fully developed third leaf from the top of tallest plant was selected from tagged plants. The leaves should be cleaned before taking the leaf area. The leaf area was measured with the help of digital leaf area meter then average was worked out and expressed in square centimetre.

3.11.2 Flowering and yield parameters

The data regarding flowering parameters *viz.* days to flowering, flowering duration, number of bracts, number of florets, rachis length and stalk length were taken from the first spike, whereas number of spikes per clump and number of spikes per plot were counted after each harvesting.

3.11.2.1 Days to flowering

The number of days required for first two bracts opening from tagged plants were calculated from the date of

planting to the first two bracts opening on heliconia inflorescence and averaged.

3.11.2.2 Flowering duration or longevity of spike *in situ* (days)

Flowering duration or longevity of spike *in situ* was counted by the number of days from first two bracts opening to the wilting of whole flower from labelled plants and averaged.

3.11.2.3 Number of bracts

The numbers of bracts per spike produced by each first flower were counted from tagged plants and averaged.

3.11.2.4 Number of florets per bract

The numbers of florets produced by each first spike from lower bract were counted from tagged plants and later average was calculated.

3.11.2.5 Rachis length (cm)

The rachis length of flower was measured from basal bract of spike to top bract of spike with the help of standard scale from tagged plants and average was calculated.

3.11.2.6 Stalk length (cm)

The length of stalk was measured from basal portion of stalk to the beginning point of lower bract with the help of standard scale and average was worked out.

3.11.2.7 Number of spikes per clump per year

After each harvesting, the number of spikes from tagged plants was recorded till the last harvesting and added to obtain the overall yield of individual clump.

3.11.2.8 Number of spikes per plot and 1000 m² per year

After each harvesting, the number of spikes from all the plants per plot were counted and spikes per 1000 m² were calculated on the basis of spikes per plot till the last harvesting and added to obtain the overall yield.

3.11.2.9 Overall presentability

Overall presentability was measured on visual basis with respect to number of bracts, rachis length, stalk length and general appearance then average was worked out.

3.11.2.10 Vase life (days)

The heliconia flowers were harvested with the help of secateurs when first two bracts open. Flowers were immediately placed in the bucket containing water than kept in flasks containing 150 ml of distilled water in laboratory. The observations were recorded daily.

The basal 1-2 cm portion of stalk was cut off with sharp blade to prevent infection and regularize the flow of water. Water in the flask was also changed on alternate days. The vase life in days was calculated from the date of harvesting of spike to senescence of the last bract.

3.12 Pigment content

3.12.1 Chlorophyll content (mg/g)

Chlorophyll content in leaves was determined by DMSO (Dimethylsulphoxide) method. Finely chopped 25 mg of plant leaf samples were weighed in graduated test tubes. 10 ml of DMSO was added in each test tube. The tubes were incubated at 65°C for 3 hours and thereafter cool at room temperature and the optical density (OD) was recorded at 480, 663 and 645 nm wavelength by taking DMSO solution as blank. Chlorophyll content was calculated using the following formula:

Total chlorophyll mg/g tissue

$$= 22.2 (OD \text{ at } 645) + 8.02 (OD \text{ at } 663) \times \frac{V}{W(g)}$$

Where,

A = Length of light path (1 cm)

V = Volume of extract

W = Fresh weight of sample

A₆₄₅ = Absorbance at 645 nm

A₆₆₃ = Absorbance at 663 nm

3.12.2 Anthocyanin content (mg/g)

Procedure followed for estimation of anthocyanin pigment from heliconia flowers is given below.

A sample of known weight (1 to 5 g) of the second lower bract of heliconia spike was taken and macerated nicely with the help

of a mortar and pestle. It was mixed with 20 ml mixture of 95% ethanol and 1.5 N HCl (In the proportion of 85:15). This mixture was transferred in to another beaker, covered with para film and stored for overnight at 4°C. Next day; the mixture was filtered through No.1 Whatman filter paper in a funnel and the filtrate was collected in a flask. After the filtration, the macerate (left in the filter paper) was again mixed with 10 ml of extracting solvent and filtered through another no.1 Whatman filter paper into the flask containing earlier filtrate. The final volume was made to 30 ml by the addition of extraction solvent. From that solution, 10 ml was taken into another beaker and made to 20 ml by the addition of extracting solvent. This solution was stored in dark for two hrs at room temperature; the spectrophotometer reading was recorded at 535 nm wavelength then the anthocyanin pigment was estimated according the following formula:

Anthocyanin content: (mg/g)

$$= D_{535} \times \text{Dilution factor} \times 10 / \text{Avg} E_{535}^{1\%}$$

$$= (D_{535} \times \text{Dilution factor}) / 98.2$$

Where,

D_{535} = O.D. at 535 nm wavelength

Dilution factor = (Original extract x dilution amount)/extract taken
for dilution

$$= (30 \times 20) / 10$$

$$= 60$$

3.12.3 Total soluble sugar (TSS) (mg/g)

In 1 ml of water (from the solution prepared to measure membrane stability index), 4 ml of 0.2 % anthrone reagent (200 mg in 100 ml H₂SO₄) was added in each test tube and placed in ice cold water. Reagent blank was prepared by adding 1 ml of distilled water and 4 ml of anthrone reagent. The intensity of colour was measured at 600 nm wavelength on spectrophotometer. A standard curve was prepared using 10 mg glucose per 100 ml distilled water. TSS content was calculated using the following formula:

$$\text{TSS (mg/g)} = \text{Sample O.D.} \times \text{standard O.D.} \times \text{dilution factor}$$

3.13 Other characteristics

3.13.1 Pest and disease incidences

No serious pests and diseases were reported during experimental period.

3.14 Economics

In order to evaluate the effectiveness of different treatments and to ascertain the most remunerative treatment, the expenses incurred in all cultural operations from preparation of land to harvest of crop includes as cost of inputs *viz.* net house, CCC, MH, TIBA, PCB, fertilizers, sprouted rhizomes of heliconia, irrigation, etc. applied to each treatment were computed.

The gross realization worked out on the basis of yield of spikes, suckers of each treatment and the prevailing market price of flower. The net realization per 1000 m² was calculated by deducting the cost of cultivation from the gross realization for

each treatment. The benefit cost ratio (BCR) was calculated on the basis of the formula given below:

$$\text{BCR} = \frac{\text{Net realization (Rs. per 1000 m}^2\text{)}}{\text{Total cost of cultivation (Rs. per 1000 m}^2\text{)}}$$

3.15 Statistical analysis

The data on various observations were recorded during the course of investigation were statistically analyzed using Randomized Block Design (RBD) as suggested by Panse and Sukhatme (1967). The appropriate standard error of mean (S.E.m.±) and the critical difference (C.D.) were calculated at 5 per cent level of probability. Data have been depicted by suitable figures with the appropriate tables.



EXPERIMENTAL

RESULTS

IV. EXPERIMENTAL RESULTS

The results of the experiment entitled "Effect of plant growth retardants on the growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. 'Red Torch' under 50 per cent shade net condition" was carried out at Floriculture Research Farm, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during 2012-2013 are presented in this chapter. The data collected during experimentation were subjected to statistical analysis using Randomized Block Design. The results pertaining to all aspects have been presented and described along with statistical implication under the headings and subheadings.

In support of tabular presentation, the graphical depictions of data for various plant attributes have also been included for better understanding.

4.1 Effect of growth retardants on vegetative characters

The data on vegetative characters viz. plant height, number of leaves per plant, number of suckers per clump and leaf area as influenced by different growth retardants were recorded at 3rd, 6th, 9th and 12th months after planting of suckers, except for leaf area during the experimentation and are presented in Tables 4.1 to 4.4 and also illustrated graphically in Figs. 4.1 to 4.4.

4.1.1 Plant height (cm)

The data pertaining to plant height as affected by different treatments of growth retardants have been presented in

Table 4.1 and graphically depicted in Fig.4.1. Among the various plant growth retardants, paclobutrazol @ 300 ppm extremely suppressed the plant height.

4.1.1.1 Plant height at 3 MAP

It is explicit from the data that plant height of heliconia was significantly influenced by plant growth retardants. Application of paclobutrazol @ 300 ppm (T₈) recorded minimum plant height (24.86 cm) which was on par with paclobutrazol @ 150 ppm i.e. T₇ (25.73 cm) and followed by T₆ i.e. TIBA @ 30 ppm (59.53 cm). Whereas, water drenching (control) recorded maximum plant height (73.20 cm) which was statistically on par with MH @ 25 ppm i.e. T₃ (67.26 cm), CCC @ 200 ppm i.e. T₂ (68.60 cm) and CCC @ 100 ppm i.e. T₁ (70.43 cm).

4.1.1.2 Plant height at 6 MAP

It is apparent from the data that minimum plant height (25.95 cm) was registered in paclobutrazol @ 300 ppm i.e. T₈ which was at par with paclobutrazol @ 150 ppm i.e. T₇ (26.76 cm) and followed by MH @ 50 ppm i.e. T₄ (97.78 cm). While, maximum plant height (117.40 cm) was registered in control (water drenching) which was at par with MH @ 25 ppm i.e. T₃ (101.56 cm), CCC @ 100 ppm i.e. T₁ (102.44 cm), TIBA @ 30 ppm i.e. T₆ (103.15 cm) and TIBA @ 15 ppm i.e. T₅ (105.16 cm).

4.1.1.3 Plant height at 9 MAP

Significant difference in plant height at 9 MAP was observed due to various growth retardants, paclobutrazol @ 300

ppm i.e. T₈ again registered minimum plant height (27.20 cm) which was on par with T₇ (28.40 cm) and followed by TIBA @ 30 ppm i.e. T₆ (133.46 cm). While, the maximum plant height (163.93 cm) was recorded in control (T₉) which was at par with MH @ 25 ppm T₃ (145.24 cm), CCC @ 200 ppm i.e. T₂ (145.86 cm) and CCC @ 100 ppm i.e. T₁ (152.93 cm).

4.1.1.4 Plant height at 12 MAP

Even at 12 months after planting, lowest height was recorded in T₈ (49.60 cm), which was found on par with T₇ where plant height of 54.33 cm was registered and followed by T₆ (140.26 cm). Maximum plant height (159.46 cm) was recorded in control which was on par with T₅ (144.86 cm), T₃ (144.93 cm), T₂ (145.73 cm) and T₁ (154.73 cm).

4.1.2 Number of leaves per plant

Data concerning to number of leaves per plant influenced by application of various growth retardants are presented in Table 4.2 and graphically depicted in Fig.4.2.

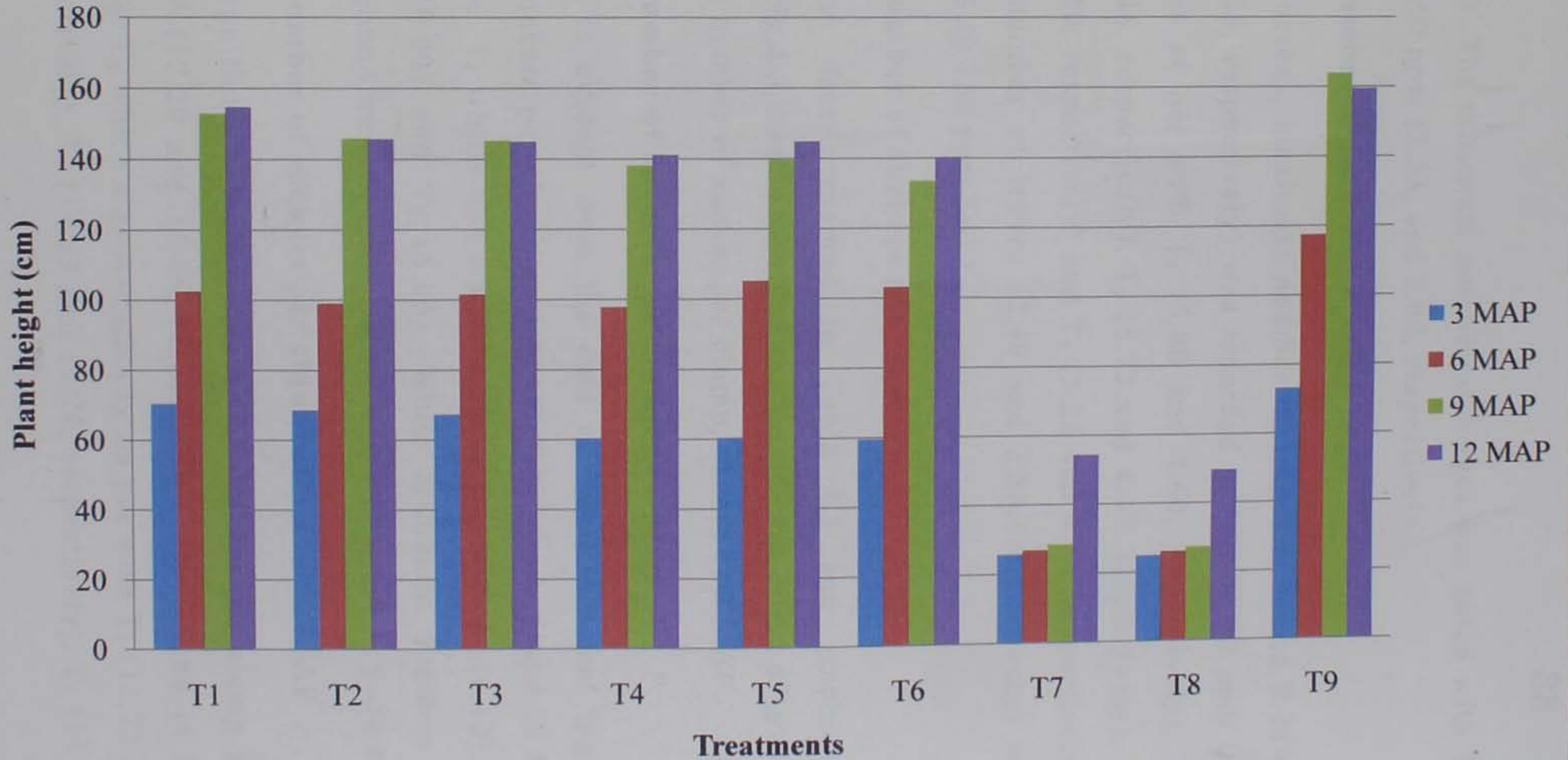
4.1.2.1 Number of leaves at 3 and 12 MAP

Among different growth retardant treatments, significantly higher number of leaves at 3 and 12 MAP (4.60 and 4.33, respectively) was observed with the application of MH @ 50 ppm i.e. T₄, which was statistically at par with CCC @ 100 ppm i.e. T₁ (4.26 and 3.93, respectively), T₃ (4.23 and 3.90, respectively), T₂ (4.20 and 3.66, respectively), T₆ (4.16 and 3.86,

Table 4.1: Effect of plant growth retardants on plant height of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Plant height (cm) | | | |
|--------------------------------|-------------------|--------|--------|--------|
| | 3 MAP | 6 MAP | 9 MAP | 12 MAP |
| T ₁ – CCC @ 100 ppm | 70.43 | 102.44 | 152.93 | 154.73 |
| T ₂ – CCC @ 200 ppm | 68.60 | 99.067 | 145.86 | 145.73 |
| T ₃ – MH @ 25 ppm | 67.26 | 101.56 | 145.24 | 144.93 |
| T ₄ – MH @ 50 ppm | 60.40 | 97.78 | 138.13 | 141.13 |
| T ₅ – TIBA @ 15 ppm | 60.46 | 105.16 | 139.56 | 144.86 |
| T ₆ – TIBA @ 30 ppm | 59.53 | 103.15 | 133.46 | 140.26 |
| T ₇ – PCB @ 150 ppm | 25.73 | 26.76 | 28.40 | 54.33 |
| T ₈ – PCB @ 300 ppm | 24.86 | 25.95 | 27.20 | 49.60 |
| T ₉ – Control | 73.20 | 117.40 | 163.93 | 159.46 |
| S.Em. _± | 3.35 | 5.49 | 7.30 | 5.77 |
| C.D. at 5 % | 10.06 | 16.47 | 21.89 | 17.32 |
| C.V.% | 10.24 | 10.99 | 10.59 | 7.93 |

Fig. 4.1 : Effect of plant growth retardants on plant height of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



srespectively). The minimum number of leaves was noted with T₇ i.e. PCB @ 150 ppm (2.33, and 3.06, respectively).

4.1.2.2 Number of leaves at 6 and 9 MAP

Whereas, maximum number of leaves at 6 and 9 MAP (6.20 and 4.66, respectively) was recorded in MH @ 50 ppm i.e. T₄ which was at par with T₁ (5.80 and 4.60, respectively), T₃ (5.76 and 4.46, respectively), T₂ (5.73 and 4.43, respectively), T₆ (5.60 and 4.20, respectively) and T₅ (5.26 and 4.10, respectively). The lowest number of leaves (2.40 and 2.86, respectively) was found in PCB @ 150 ppm i.e. T₇.

4.1.3 Number of suckers per clump

The data presented in Table 4.3 and graphically depicted in Fig.4.3 clearly revealed the significant effect of growth retardants on number of sucker per clump, except at 3 MAP.

4.1.3.1 Number of suckers per clump at 6 MAP

It is evident from the data of Table 4.3 that higher number of suckers per clump at 6 MAP (6.13) were found in MH @ 50 ppm i.e. T₄ which was statistically on par with T₁ (6.10), T₃ (6.03), T₂ (6.00) and T₆ (5.06). While minimum numbers of suckers per clump were observed in PCB @ 150 ppm i.e. T₇ (4.46).

4.1.3.2 Number of suckers per clump at 9 and 12 MAP

Significantly higher number of suckers per clump at 9 and 12 MAP (12.20 and 15.86, respectively) were found in MH @ 50 ppm i.e. T₄ which was statistically on par with T₁ (11.73 and 15.40, respectively), T₃ (11.33 and 15.20, respectively), T₂ (14.13,

Table 4.2: Effect of plant growth retardants on number of leaves of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Number of leaves/plant | | | |
|--------------------------------|------------------------|-------|-------|--------|
| | 3 MAP | 6 MAP | 9 MAP | 12 MAP |
| T ₁ – CCC @ 100 ppm | 4.26 | 5.80 | 4.60 | 3.93 |
| T ₂ – CCC @ 200 ppm | 4.20 | 5.73 | 4.43 | 3.66 |
| T ₃ – MH @ 25 ppm | 4.23 | 5.76 | 4.46 | 3.90 |
| T ₄ – MH @ 50 ppm | 4.60 | 6.20 | 4.66 | 4.33 |
| T ₅ – TIBA @ 15 ppm | 3.80 | 5.26 | 4.10 | 3.53 |
| T ₆ – TIBA @ 30 ppm | 4.16 | 5.60 | 4.20 | 3.86 |
| T ₇ – PCB @ 150 ppm | 2.33 | 2.40 | 2.86 | 3.06 |
| T ₈ – PCB @ 300 ppm | 2.93 | 3.33 | 3.20 | 3.10 |
| T ₉ – Control | 3.53 | 4.80 | 4.00 | 3.33 |
| S.Em. _± | 0.24 | 0.33 | 0.20 | 0.24 |
| C.D. at 5 % | 0.73 | 1.01 | 0.60 | 0.74 |
| C.V.% | 11.28 | 11.67 | 8.55 | 11.82 |

Fig. 4.2: Effect of plant growth retardants on number of leaves of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

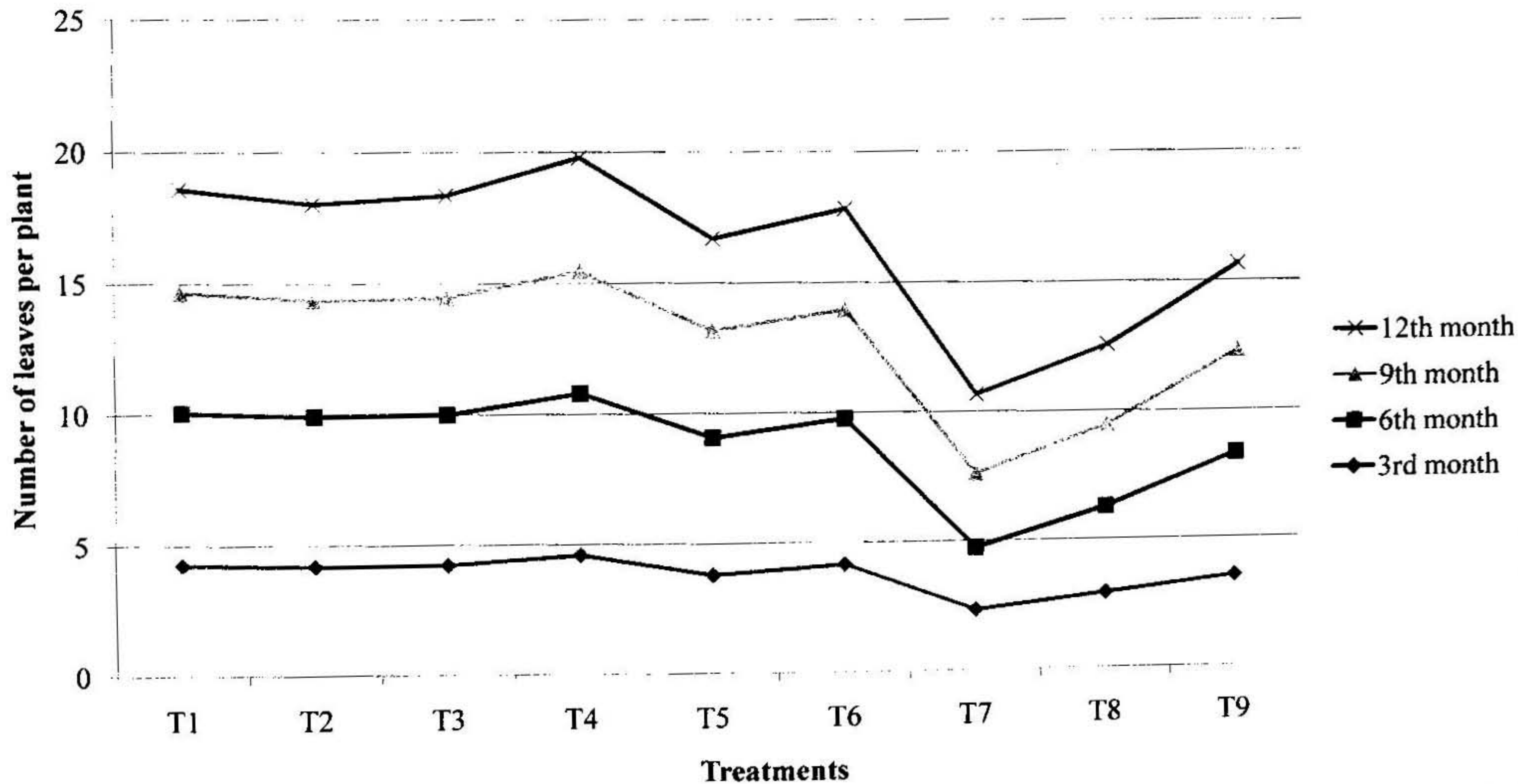
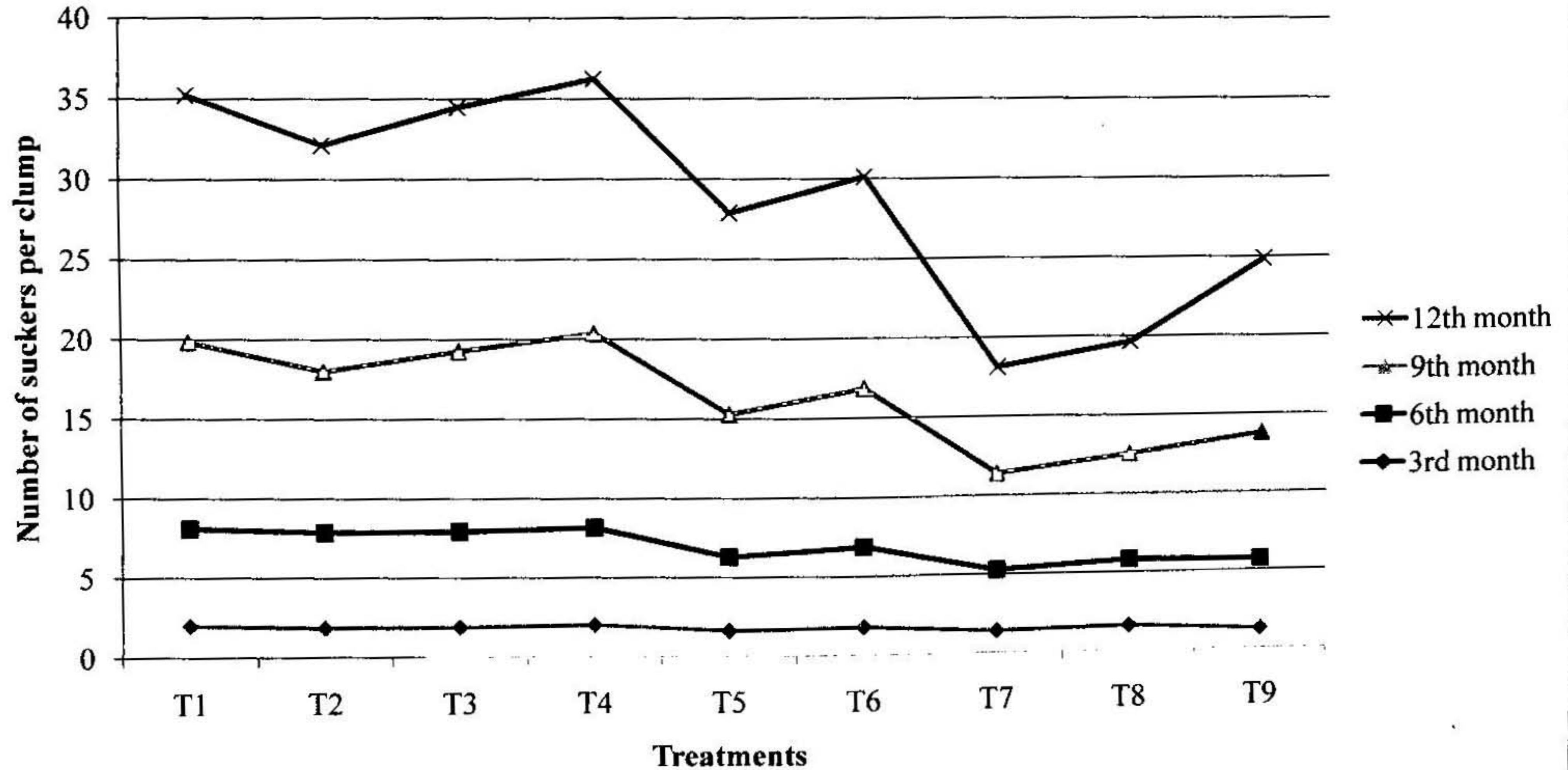


Table 4.3: Effect of plant growth retardants on number of suckers per clump of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Number of suckers per clump | | | |
|--------------------------------|-----------------------------|-------|-------|--------|
| | 3 MAP | 6 MAP | 9 MAP | 12 MAP |
| T ₁ – CCC @ 100 ppm | 2.00 | 6.10 | 11.73 | 15.40 |
| T ₂ – CCC @ 200 ppm | 1.87 | 6.00 | 10.13 | 14.13 |
| T ₃ – MH @ 25 ppm | 1.90 | 6.03 | 11.33 | 15.20 |
| T ₄ – MH @ 50 ppm | 2.03 | 6.13 | 12.20 | 15.86 |
| T ₅ – TIBA @ 15 ppm | 1.63 | 4.66 | 9.00 | 12.60 |
| T ₆ – TIBA @ 30 ppm | 1.80 | 5.06 | 10.00 | 13.26 |
| T ₇ – PCB @ 150 ppm | 1.40 | 3.86 | 6.13 | 6.73 |
| T ₈ – PCB @ 300 ppm | 1.60 | 4.20 | 6.73 | 7.13 |
| T ₉ – Control | 1.27 | 4.46 | 8.06 | 11.06 |
| S.Em. _± | 0.16 | 0.35 | 0.63 | 0.72 |
| C.D. at 5 % | NS | 1.06 | 1.89 | 2.16 |
| C.V.% | 16.70 | 11.94 | 11.54 | 10.11 |

Fig. 4.3 : Effect of plant growth retardants on number of suckers per clump of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.





3 MAP

12 MAP



Plate - III : Effect of plant growth retardants on vegetative growth



6 MAP

Plate - IV: Effect of paclobutrazol on vegetative growth

at 12th month). Whereas, minimum number of suckers per clump were observed (6.13 and 6.73, respectively) in (T₇) PCB @ 150 ppm.

4.1.4 Leaf area (cm²)

A perusal of data revealed that leaf area of top third leaf of heliconia at 12th month after planting was significantly affected by application of various growth retardants and their concentrations (Table 4.4 and Fig.4.4).

Maximum leaf area (477.73 cm²) was measured with the application of MH @ 50 ppm i.e.T₄, which was statistically on par with CCC @ 100ppm i.e.T₁ (458.98 cm²) and MH @ 25 ppm i.e.T₃ (441.51 cm²). While minimum leaf area (150.50 cm²) was recorded with (T₇) PCB @ 150 ppm.

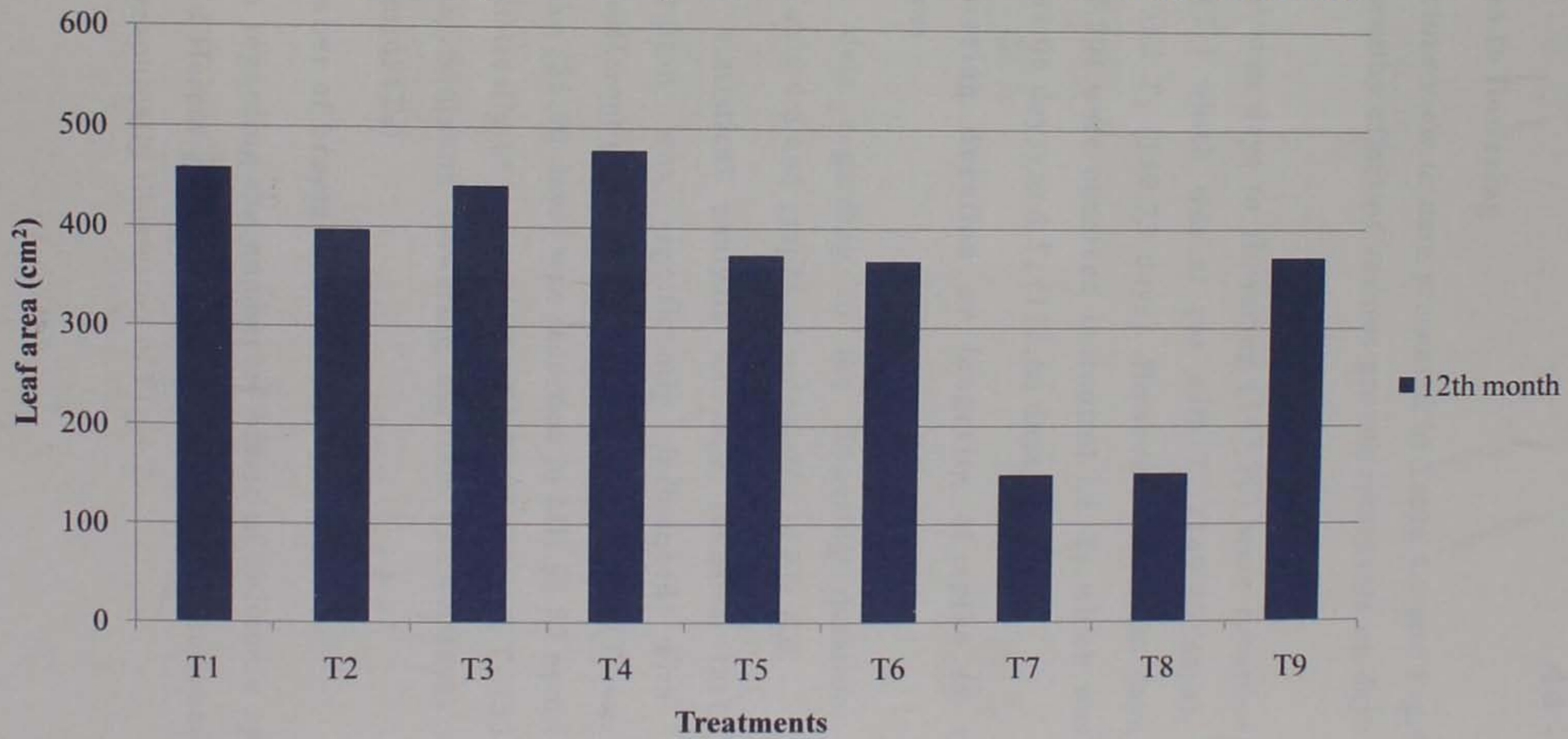
4.2 Effect of growth retardants on flowering and yield characters

The data regarding various flowering and yield parameters of the heliconia var. Red Torch as influenced by growth retardants were recorded during the experimentation at different concentrations, it is presented in Tables 4.5 to 4.14 and graphically illustrated in Figs. 4.5 to 4.14. Among the various growth retardants, paclobutrazol @ 150 ppm and 300 ppm failed to produce flowering up to 12 MAP in heliconia var. Red Torch.

Table 4.4: Effect of plant growth retardants on leaf area of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Leaf area (cm ²) |
|--------------------------------|------------------------------|
| T ₁ – CCC @ 100 ppm | 458.98 |
| T ₂ – CCC @ 200 ppm | 397.20 |
| T ₃ – MH @ 25 ppm | 441.51 |
| T ₄ – MH @ 50 ppm | 477.73 |
| T ₅ – TIBA @ 15 ppm | 373.28 |
| T ₆ – TIBA @ 30 ppm | 367.33 |
| T ₇ – PCB @ 150 ppm | 150.50 |
| T ₈ – PCB @ 300 ppm | 152.03 |
| T ₉ – Control | 371.18 |
| S.Em. _± | 22.96 |
| C.D. at 5 % | 68.84 |
| C.V.% | 11.22 |

Fig. 4.4 : Effect of plant growth retardants on leaf area (cm²) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



4.2.1 Days to flowering

A close view to data presented in Table 4.5 and Fig.4.5 revealed note worthy effect of various growth retardants on days to flowering.

Minimum days to flowering (147.20) were recorded in 50 ppm MH (T₄) which was at par with T₁ (149.86 days), T₃ (151.66 days) and T₂ (159.73 days). However, maximum days to flowering (197.20) were observed in control i.e. T₉ which was at par with T₆ (188.06 days) and T₅ (175.66 days).

4.2.2 Flowering duration or longevity of spike *in situ* (days)

The data regarding to the flowering duration are mentioned in Table 4.6 and graphically depicted in Fig.4.6.

The statistical analysis of data revealed that the flowering duration was significantly influenced with the application of different growth retardants. The maximum flowering duration of spike (55.40 days) was recorded in MH @ 50 ppm (T₄) which was statistically at par with T₁ (53.33 days) and T₃ (53.20 days). Whereas, minimum flowering duration (38.40 days) was observed in control (T₉).

4.2.3 Number of bracts

Data regarding the number of bracts of heliconia spike as affected by different growth retardants have been mentioned in Table 4.7 and graphically illustrated in Fig.4.7.

Table 4.5: Effect of plant growth retardants on days to flowering of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Days to flowering |
|--------------------------------|--------------------------|
| T ₁ – CCC @ 100 ppm | 149.86 (12.25) |
| T ₂ – CCC @ 200 ppm | 159.73 (12.65) |
| T ₃ – MH @ 25 ppm | 151.66 (12.32) |
| T ₄ – MH @ 50 ppm | 147.20 (12.14) |
| T ₅ – TIBA @ 15 ppm | 175.66 (13.26) |
| T ₆ – TIBA @ 30 ppm | 188.06 (13.70) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 197.20 (14.05) |
| S.Em.± | 0.34 |
| C.D. at 5 % | 1.04 |
| C.V.% | 5.94 |

(* Data in parenthesis are square root transformed value)

Fig. 4.5 : Effect of plant growth retardants on days to flowering of heliconia (Heliconia psittacorum) var. Red Torch under 50 % shade condition.

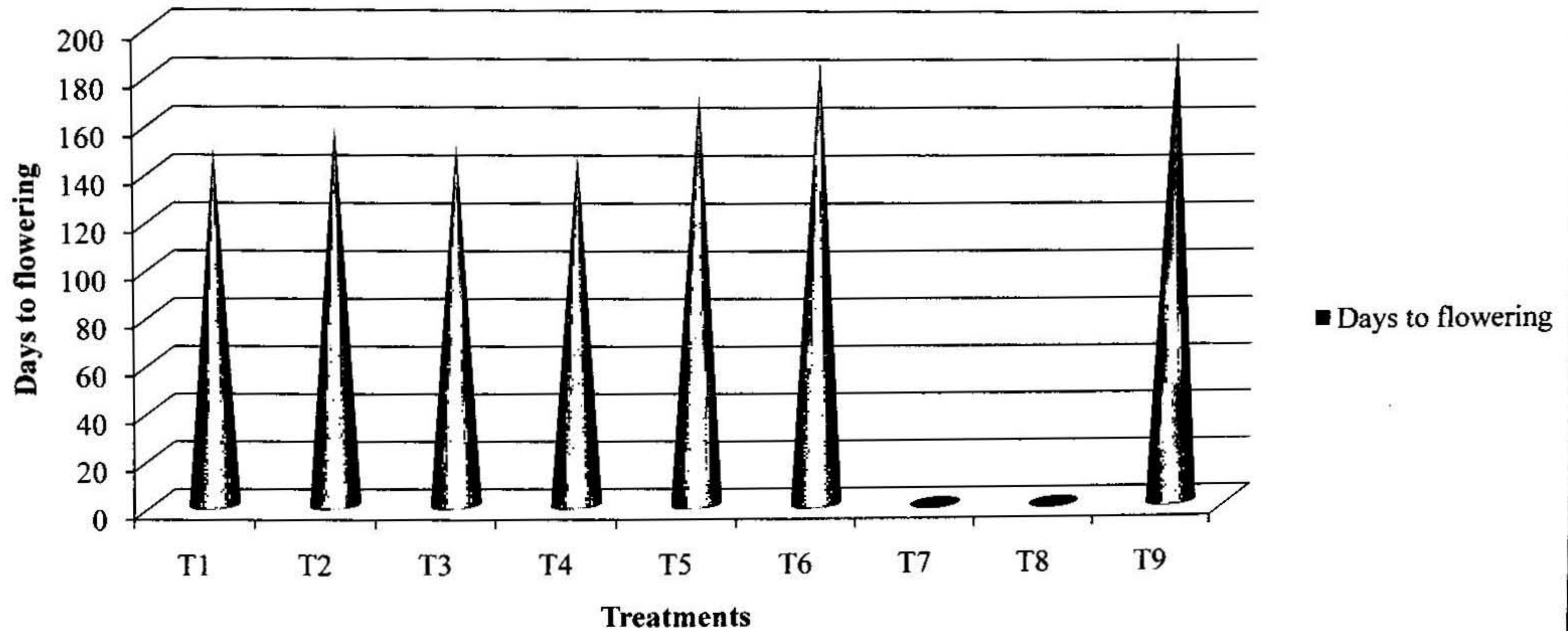


Table 4.6 : Effect of plant growth retardants on flowering duration of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Flowering duration (days) |
|--------------------------------|----------------------------------|
| T ₁ – CCC @ 100 ppm | 53.33 (7.33) |
| T ₂ – CCC @ 200 ppm | 47.07 (6.89) |
| T ₃ – MH @ 25 ppm | 53.20 (7.30) |
| T ₄ – MH @ 50 ppm | 55.40 (7.47) |
| T ₅ – TIBA @ 15 ppm | 46.60 (6.86) |
| T ₆ – TIBA @ 30 ppm | 45.20 (6.75) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 38.40 (6.23) |
| S.Em.± | 0.16 |
| C.D. at 5 % | 0.48 |
| C.V.% | 5.03 |

(* Data in parenthesis are square root transformed value)

Fig. 4.6 : Effect of plant growth retardants on flowering duration of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

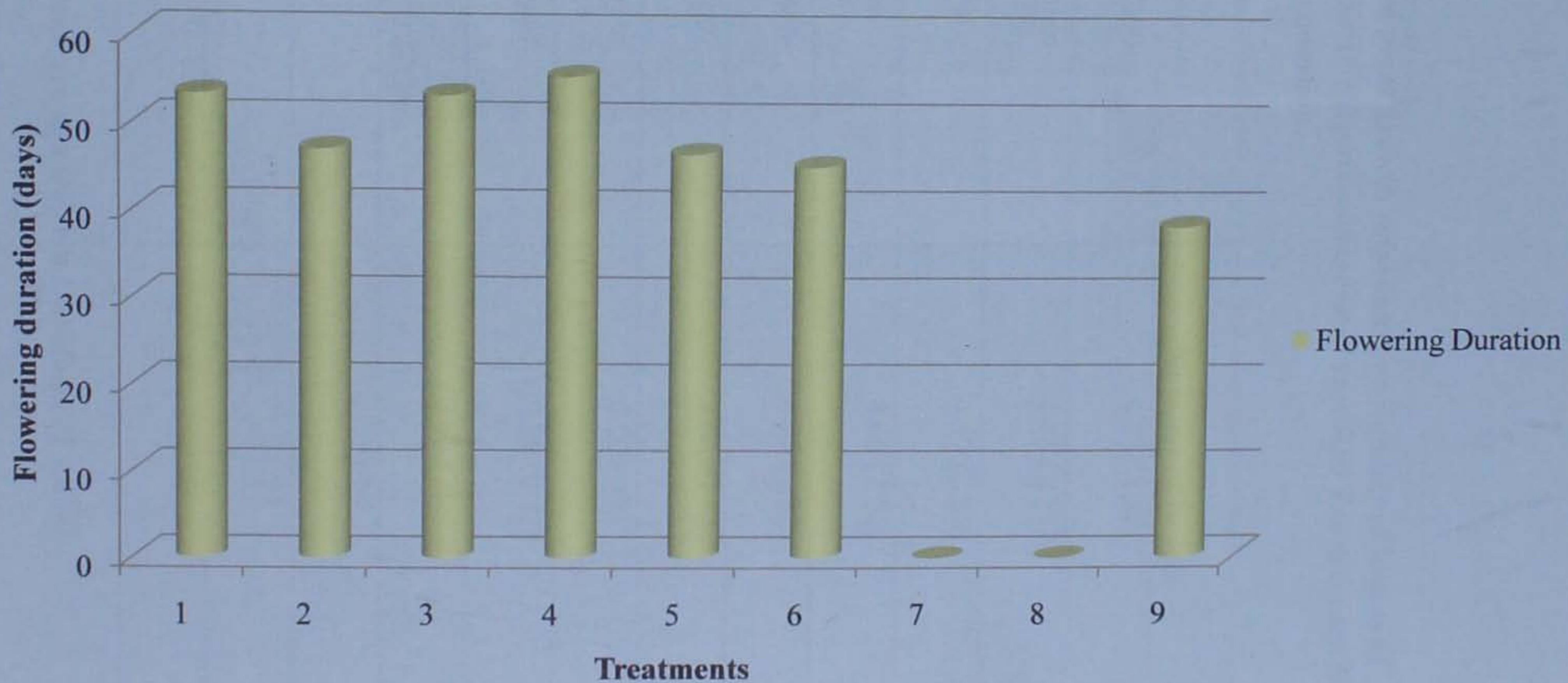


Table 4.7: Effect of plant growth retardants on number of bracts of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Number of bracts |
|--------------------------------|------------------|
| T ₁ – CCC @ 100 ppm | 4.53 (2.24) |
| T ₂ – CCC @ 200 ppm | 4.46 (2.23) |
| T ₃ – MH @ 25 ppm | 4.50 (2.24) |
| T ₄ – MH @ 50 ppm | 4.60 (2.26) |
| T ₅ – TIBA @ 15 ppm | 4.40 (2.21) |
| T ₆ – TIBA @ 30 ppm | 4.00 (2.12) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 3.93 (2.11) |
| S.Em. _± | 0.031 |
| C.D. at 5 % | 0.094 |
| C.V.% | 2.92 |

(* Data in parenthesis are square root transformed value)

Fig. 4.7 : Effect of plant growth retardants on number of bracts of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



A glance on the data clearly revealed that growth retardants had significant effect on number of bracts of heliconia flower. The result showed that significantly maximum number of bracts (4.60) were observed under MH @ 50 ppm (T₄) which was statistically at par with T₁ (4.53), T₃ (4.50), T₂ (4.46) and T₅ (4.40). While, minimum numbers of bracts (3.93) were observed in control (T₉).

4.2.4 Number of florets per bract

Number of florets per bract was significantly influenced by application of various growth retardants in heliconia var. Red Torch are presented in Table 4.8 and graphical illustrated in Fig.4.8.

An application of MH @ 50 ppm (T₄) recorded maximum florets per bract (12.06), whereas a non significant difference was observed with T₁ (11.53), T₃ (11.27) and T₂ (10.66). While lowest number of florets per bract (9.93) was recorded with drenching of water (control) i.e.T₉.

4.2.5 Rachis length (cm)

A perusal of data regarding the rachis length as influenced by various growth retardants with different concentrations are presented in Table 4.9 and graphically depicted in Fig.4.9.

It is evident from the data presented that the plants treated with MH @ 50 ppm (T₄) recorded significantly maximum in the rachis length (15.41 cm) of heliconia var. Red Torch, which

Table 4.8 : Effect of plant growth retardants on number of florets of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Number of florets per bracts |
|--------------------------------|------------------------------|
| T ₁ – CCC @ 100 ppm | 11.53 (3.46) |
| T ₂ – CCC @ 200 ppm | 10.66 (3.34) |
| T ₃ – MH @ 25 ppm | 11.27 (3.42) |
| T ₄ – MH @ 50 ppm | 12.06 (3.54) |
| T ₅ – TIBA @ 15 ppm | 10.33 (3.28) |
| T ₆ – TIBA @ 30 ppm | 10.00 (3.24) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 9.93 (3.22) |
| S.Em. _± | 0.076 |
| C.D. at 5 % | 0.228 |
| C.V.% | 4.75 |

(* Data in parenthesis are square root transformed value)

Fig. 4.8 : Effect of plant growth retardants on number of florets of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

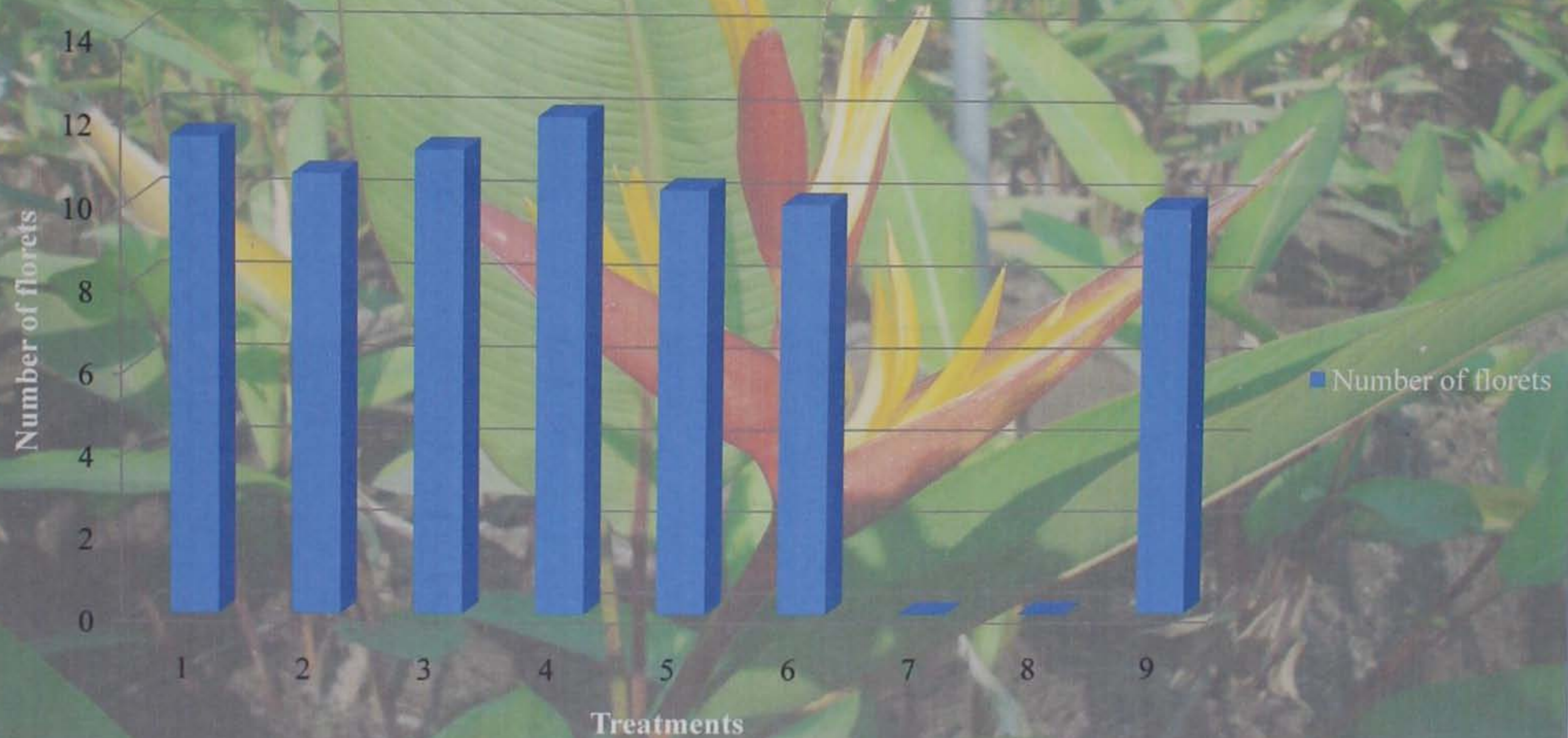
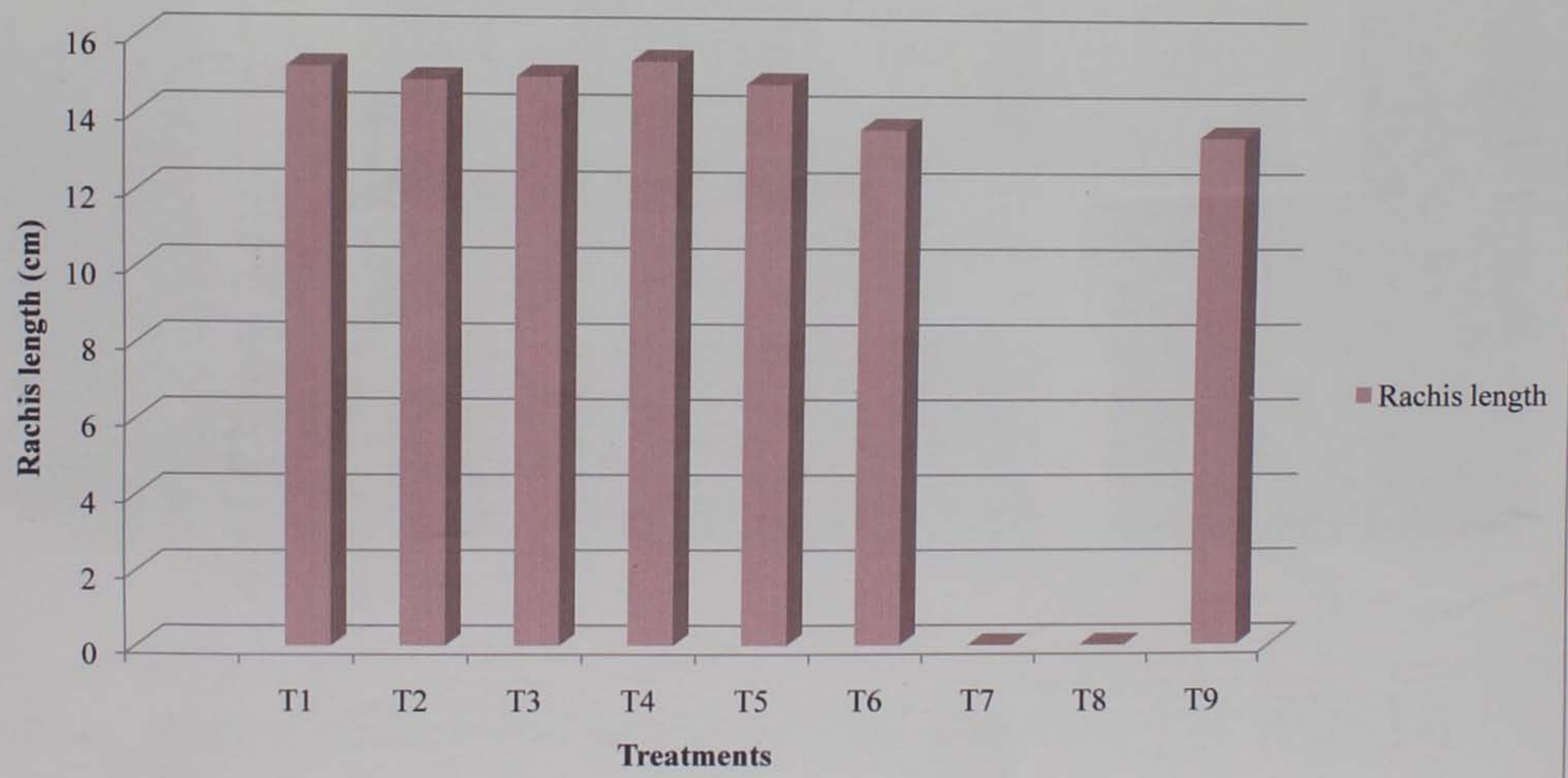


Table 4.9: Effect of plant growth retardants on rachis length (cm) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Rachis length (cm) |
|--------------------------------|--------------------|
| T ₁ – CCC @ 100 ppm | 15.23 (3.96) |
| T ₂ – CCC @ 200 ppm | 14.90 (3.92) |
| T ₃ – MH @ 25 ppm | 15.00 (3.93) |
| T ₄ – MH @ 50 ppm | 15.41 (3.98) |
| T ₅ – TIBA @ 15 ppm | 14.83 (3.91) |
| T ₆ – TIBA @ 30 ppm | 13.66 (3.75) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 13.48 (3.73) |
| S.Em. _± | 0.099 |
| C.D. at 5 % | 0.29 |
| C.V.% | 5.41 |

(* Data in parenthesis are square root transformed value)

Fig. 4.9 : Effect of plant growth retardants on rachis length (cm) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.





T₄



T₁



T₉

Plate - V : Effect of plant growth retardants on quality of heliconia spike var. Red Torch

was at par with T₁ (15.23 cm), T₃ (15.00 cm), T₂ (14.90 cm) and T₅ (14.83 cm) and T₆ (13.66). The minimum rachis length (13.48 cm) was noted in control i.e. T₉.

4.2.6 Stalk length (cm)

The data pertaining to stalk length of heliconia spike as influenced by various growth retardants have been furnished in Table 4.10 and graphically shown in Fig.4.10.

The perusal of results revealed that longest stalk (110.98 cm) was observed with application of MH @ 50 ppm (T₄) and a non significant difference found with T₁ (98.44 cm). While, the shortest stalk (71.61 cm) was found in control (T₉) which was at par with T₅ (85.68 cm) and T₆ (84.71 cm).

4.2.7 Number of spikes per clump per year

The mean data presented in Table 4.11 and graphically depicted in Fig.4.11 clearly revealed the significant effect of growth retardants on number of spikes per clump.

The trend of data in Table 4.11 showed significantly higher number of spikes per clump in MH @ 50 ppm i.e. T₄. All treatments improved the number of spikes per clump as compared to control. The maximum number of spikes (4.46) was recorded with (T₄). Whereas, minimum number of spikes per clump (2.33) were observed in control i.e. T₉.

Table 4.10: Effect of plant growth retardants on stalk length of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Stalk length (cm) |
|--------------------------------|-------------------|
| T ₁ – CCC @ 100 ppm | 98.44 (9.93) |
| T ₂ – CCC @ 200 ppm | 90.66 (9.54) |
| T ₃ – MH @ 25 ppm | 92.26 (9.61) |
| T ₄ – MH @ 50 ppm | 110.98 (10.55) |
| T ₅ – TIBA @ 15 ppm | 85.68 (9.27) |
| T ₆ – TIBA @ 30 ppm | 84.71 (9.21) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 71.61 (8.47) |
| S.Em. _± | 0.26 |
| C.D. at 5 % | 0.77 |
| C.V.% | 5.96 |

(* Data in parenthesis are square root transformed value)

Fig. 4.10 : Effect of plant growth retardants on stalk length (cm) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

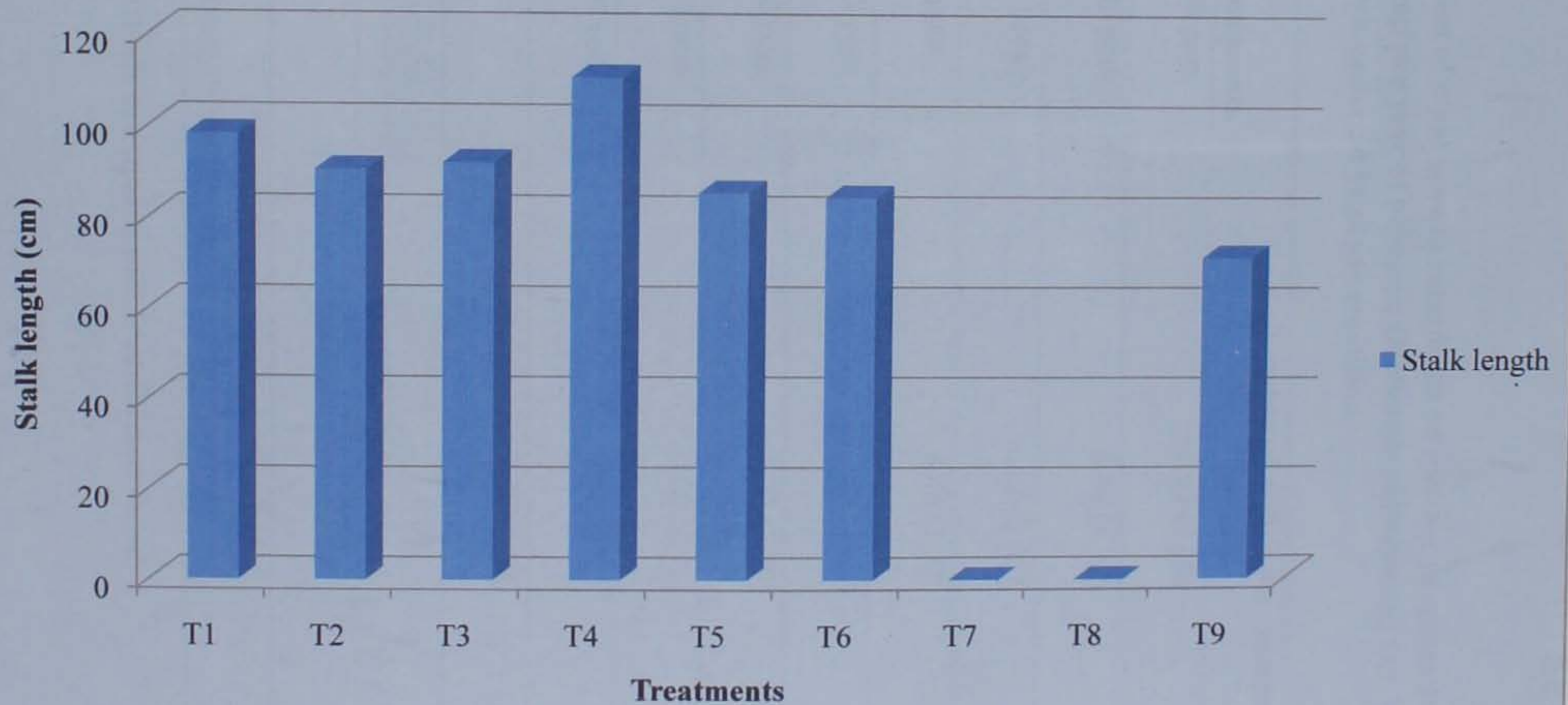


Table 4.11: Effect of plant growth retardants on number of spikes per clump per year of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Number of spikes per clumps per year |
|--------------------------------|--------------------------------------|
| T ₁ – CCC @ 100 ppm | 3.93 (2.10) |
| T ₂ – CCC @ 200 ppm | 3.46 (1.99) |
| T ₃ – MH @ 25 ppm | 3.7 (2.05) |
| T ₄ – MH @ 50 ppm | 4.46 (2.22) |
| T ₅ – TIBA @ 15 ppm | 2.83 (1.82) |
| T ₆ – TIBA @ 30 ppm | 2.73 (1.79) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.0 (0.71) |
| T ₉ – Control | 2.33 (1.68) |
| S.Em. _± | 0.03 |
| C.D. at 5 % | 0.09 |
| C.V.% | 3.16 |

(* Data in parenthesis are square root transformed value)

Fig. 4.11 : Effect of plant growth retardants on number of spikes per clump per year of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



4.2.8 Number of spikes per plot and per 1000 m² per year

The data relevant to spikes in plot and per 1000 m² per year was significantly affected by growth retardants. The results are presented in Table- 4.12 and graphically in Fig 4.12 and 4.13.

Among all the treatments, significantly maximum spikes per plot (35.66) and per 1000 m² (5572.92) was found in MH @ 50 ppm i.e. T₄, while minimum number of spikes (19.00 per plot and 2968.75 per 1000 m²) was observed in (T₉) control.

4.2.9 Overall presentability

The effect of growth retardants on overall presentability of heliconia flower spike was visually examined at 9 MAP on the basis of number of bracts, rachis length, stalk length and general appearance on the basis 10 point scale. The result with regard to qualitative parameter has been depicted in Table 4.13.

On the basis of overall presentability of heliconia spike, MH @ 50 ppm (10.0) scored maximum points and followed by CCC @ 100 ppm (9.0).

4.2.10 Vase life (days)

The mean data presented in Table-4.14 and graphically depicted in Fig.4.14 clearly revealed the significant effect of growth retardants on vase life of flowers.

The trend of data in Table-4.14 showed significantly maximum vase life (13.33 days) was recorded with the application of MH @ 50 ppm (T₄) which was statistically on par with T₁ (13 days) and T₃ (12.33 days). Whereas, minimum vase life (8.33 days) was observed in control i.e. T₉.

Table 4.12: Effect of plant growth retardants on total number of spikes per plot and per 1000 m² per year of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Spikes per plot per year | Spikes per 1000 m ² per year |
|--------------------------------|--------------------------|---|
| T ₁ – CCC @ 100 ppm | 31.33 (5.64) | 4895.83 (69.94) |
| T ₂ – CCC @ 200 ppm | 27.33 (5.27) | 4270.83 (65.35) |
| T ₃ – MH @ 25 ppm | 29.66 (5.49) | 4635.41 (68.08) |
| T ₄ – MH @ 50 ppm | 35.66 (6.01) | 5572.92 (74.64) |
| T ₅ – TIBA @ 15 ppm | 22.66 (4.80) | 3541.67 (59.42) |
| T ₆ – TIBA @ 30 ppm | 21.33 (4.67) | 3333.33 (57.71) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) | 0.00 (0.71) |
| T ₉ – Control | 19.00 (4.41) | 2968.75 (54.45) |
| S.Em. _± | 0.08 | 131.07 |
| C.D. at 5 % | 0.25 | 392.95 |
| C.V.% | 3.47 | 6.99 |

(* Data in parenthesis are square root transformed value)

Fig.4.12 : Effect of plant growth retardants on total number of spikes per plot per year of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

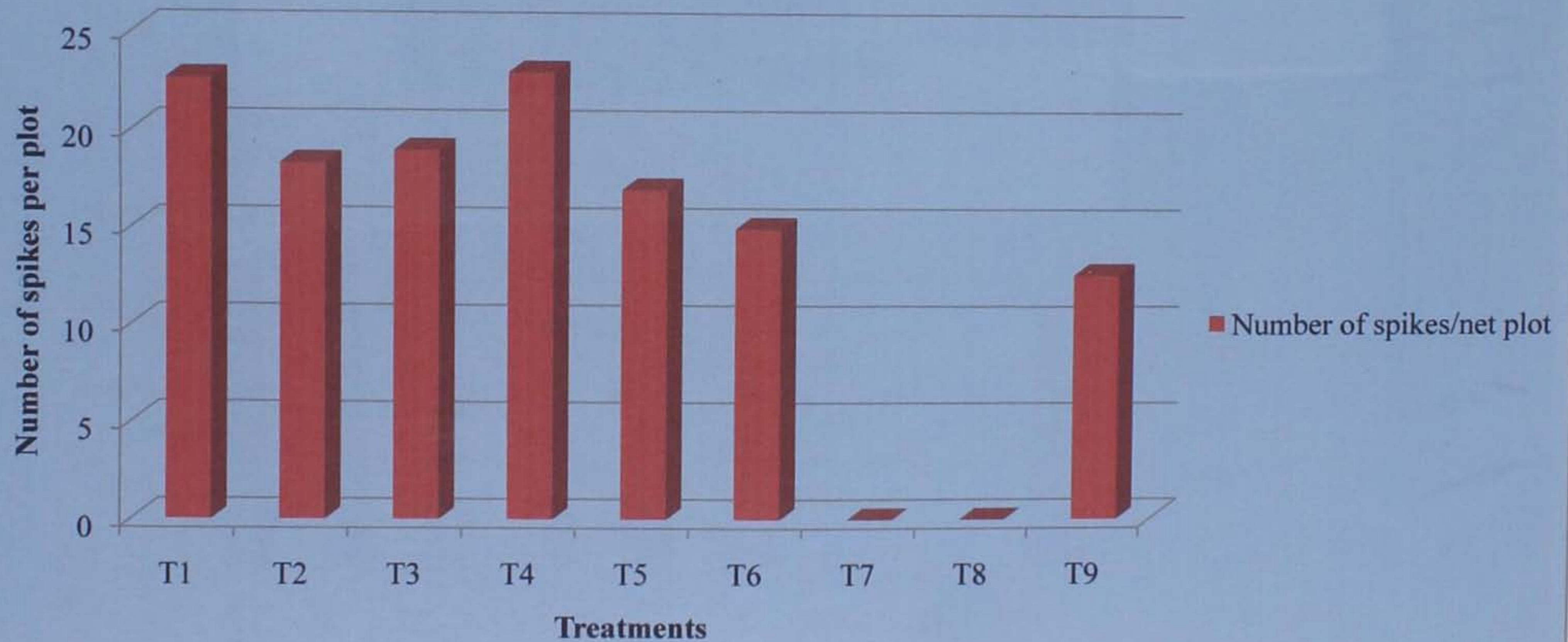


Fig. 4.13 :Effect of plant growth retardants on total number of spikes per 1000 m² per year of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

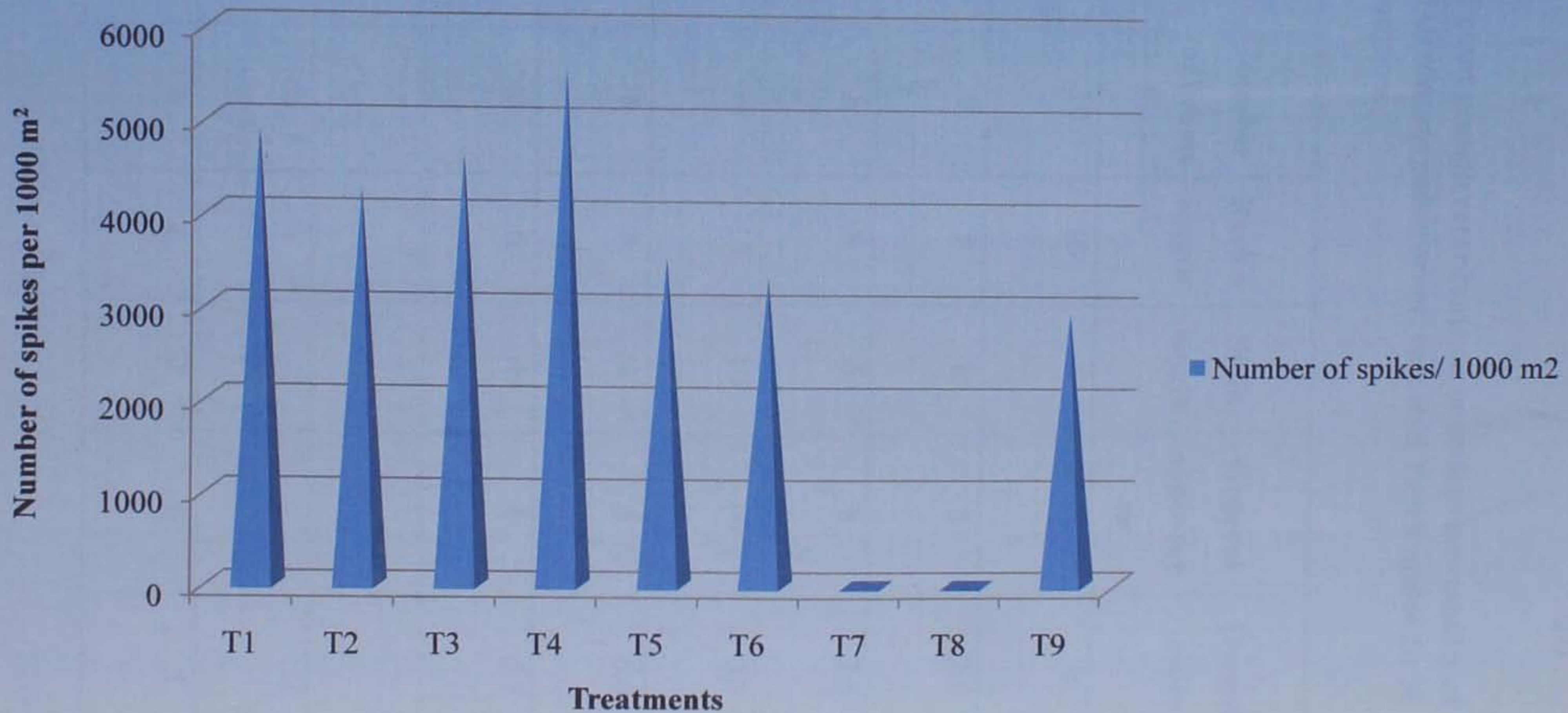


Table 4.13 : Effect of plant growth retardants on overall presentability of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

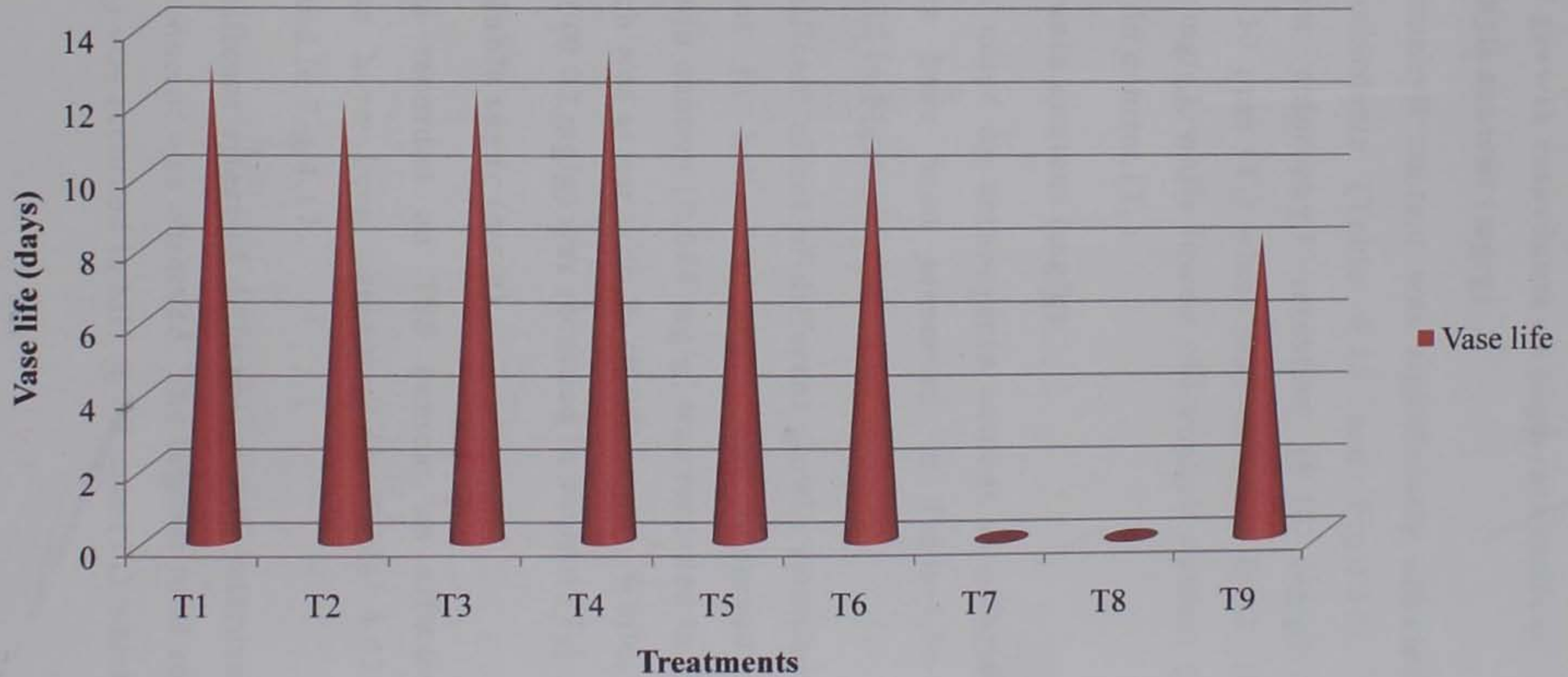
| Treatments | Number of bracts | Rachis length | Stalk length | General appearance | Overall score |
|--------------------------------|------------------|---------------|--------------|--------------------|---------------|
| T ₁ – CCC @ 100 ppm | 10 | 10 | 6 | 10 | 9 |
| T ₂ – CCC @ 200 ppm | 8 | 8 | 6 | 8 | 7.5 |
| T ₃ – MH @ 25 ppm | 8 | 8 | 6 | 8 | 7.5 |
| T ₄ – MH @ 50 ppm | 10 | 10 | 10 | 10 | 10 |
| T ₅ – TIBA @ 15 ppm | 8 | 8 | 4 | 6 | 6.5 |
| T ₆ – TIBA @ 30 ppm | 6 | 6 | 4 | 6 | 5.5 |
| T ₇ – PCB @ 150 ppm | - | - | - | - | - |
| T ₈ – PCB @ 300 ppm | - | - | - | - | - |
| T ₉ – Control | 6 | 6 | 2 | 6 | 5 |

Table 4.14: Effect of plant growth retardants on vase life of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Vase life (days) |
|--------------------------------|------------------|
| T ₁ – CCC @ 100 ppm | 13.00 (3.67) |
| T ₂ – CCC @ 200 ppm | 12.00 (3.53) |
| T ₃ – MH @ 25 ppm | 12.33 (3.58) |
| T ₄ – MH @ 50 ppm | 13.33 (3.71) |
| T ₅ – TIBA @ 15 ppm | 11.33 (3.43) |
| T ₆ – TIBA @ 30 ppm | 11.00 (3.38) |
| T ₇ – PCB @ 150 ppm | 0.00 (0.71) |
| T ₈ – PCB @ 300 ppm | 0.00 (0.71) |
| T ₉ – Control | 8.33 (2.97) |
| S.Em. _± | 0.05 |
| C.D. at 5 % | 0.15 |
| C.V.% | 3.23 |

(* Data in parenthesis are square root transformed value)

Fig. 4.14 : Effect of plant growth retardants on vase life of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



4.3 Effect of growth retardants on pigments content

4.3.1 Chlorophyll content (mg/g)

The chlorophyll content was significantly affected by different growth retardants (Table 4.15 and Fig.4.15). The significantly highest chlorophyll retention (0.14 mg/g) was recorded in MH @ 50 ppm (T₄) which was followed by T₁ (0.12 mg/g) and T₃ (0.11 mg/g), while lowest chlorophyll content (0.03 mg/g) was recorded in control (T₉).

4.3.2 Anthocyanin content (mg/g)

The data noted on anthocyanin content as affected by different treatments have been presented in Table-4.16 and graphically illustrated in Fig.4.16.

The significant effect of different growth retardants on anthocyanin content in heliconia bract was observed. The maximum anthocyanin content (0.084 mg/g) was recorded in T₄ i.e. MH @ 50 ppm which was at par with T₁ (0.083 mg/g). While, least anthocyanin content (0.02 mg/g) was recorded in control (T₉).

4.3.3 Total soluble sugar (mg/g)

The data recorded on TSS content as affected by different treatments have been presented in Table 4.17 and graphically illustrated in Fig.4.17.

The significant effect of different growth retardants on total soluble sugar content was observed. The highest total soluble sugar (171.24 mg/g) was recorded in MH @ 50 ppm (T₄) which was

Table 4.15: Effect of plant growth retardants on chlorophyll content of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Chlorophyll (mg/g) |
|--------------------------------|--------------------|
| T ₁ – CCC @ 100 ppm | 0.12 |
| T ₂ – CCC @ 200 ppm | 0.07 |
| T ₃ – MH @ 25 ppm | 0.11 |
| T ₄ – MH @ 50 ppm | 0.14 |
| T ₅ – TIBA @ 15 ppm | 0.06 |
| T ₆ – TIBA @ 30 ppm | 0.05 |
| T ₇ – PCB @ 150 ppm | 0.05 |
| T ₈ – PCB @ 300 ppm | 0.04 |
| T ₉ – Control | 0.03 |
| S.Em. _± | 0.002 |
| C.D. at 5 % | 0.007 |
| C.V.% | 5.59 |

Fig. 4.15 : Effect of plant growth retardants on chlorophyll content (mg/g) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

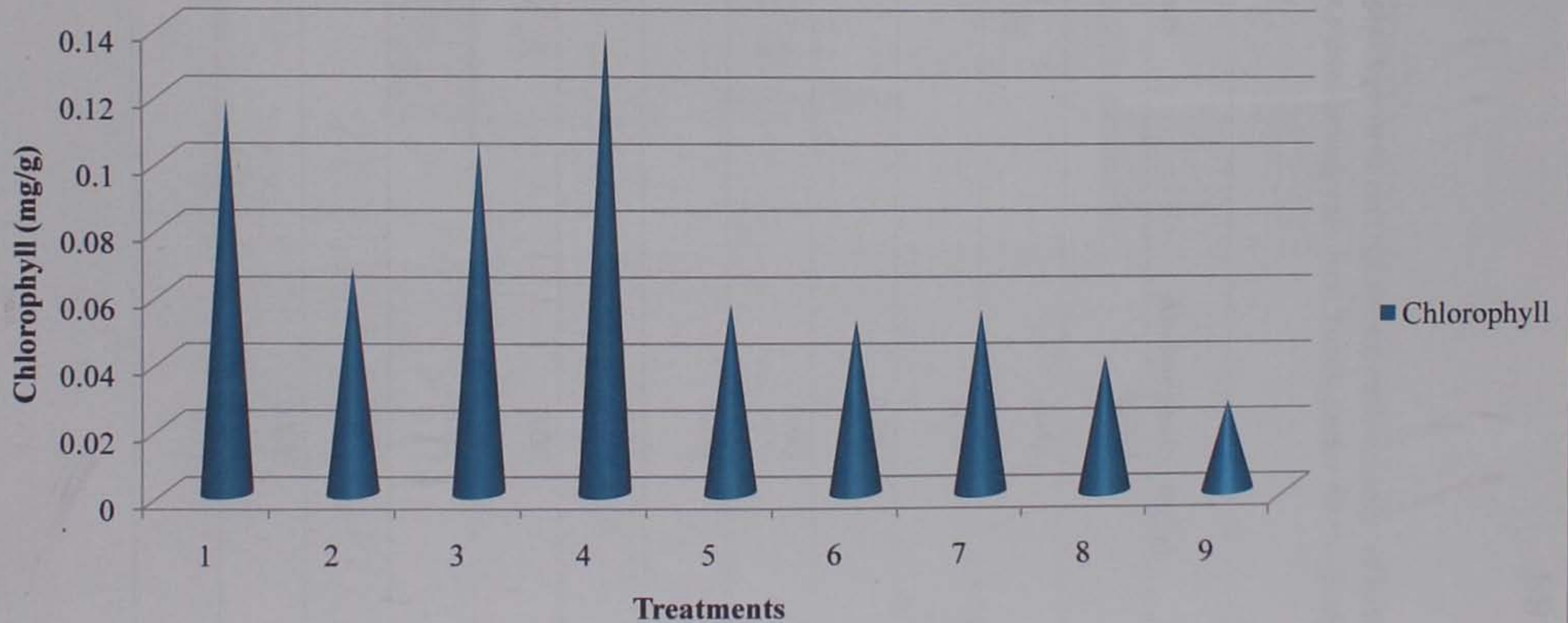


Table 4.16: Effect of plant growth retardants on anthocyanin of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Anthocyanin (mg/g) |
|--------------------------------|--------------------|
| T ₁ – CCC @ 100 ppm | 0.083 |
| T ₂ – CCC @ 200 ppm | 0.06 |
| T ₃ – MH @ 25 ppm | 0.07 |
| T ₄ – MH @ 50 ppm | 0.084 |
| T ₅ – TIBA @ 15 ppm | 0.06 |
| T ₆ – TIBA @ 30 ppm | 0.03 |
| T ₇ – PCB @ 150 ppm | 0.00 |
| T ₈ – PCB @ 300 ppm | 0.00 |
| T ₉ – Control | 0.02 |
| S.Em.± | 0.001 |
| C.D. at 5 % | 0.003 |
| C.V.% | 4.73 |

Fig. 4.16 : Effect of plant growth retardants on anthocyanin content (mg/g) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

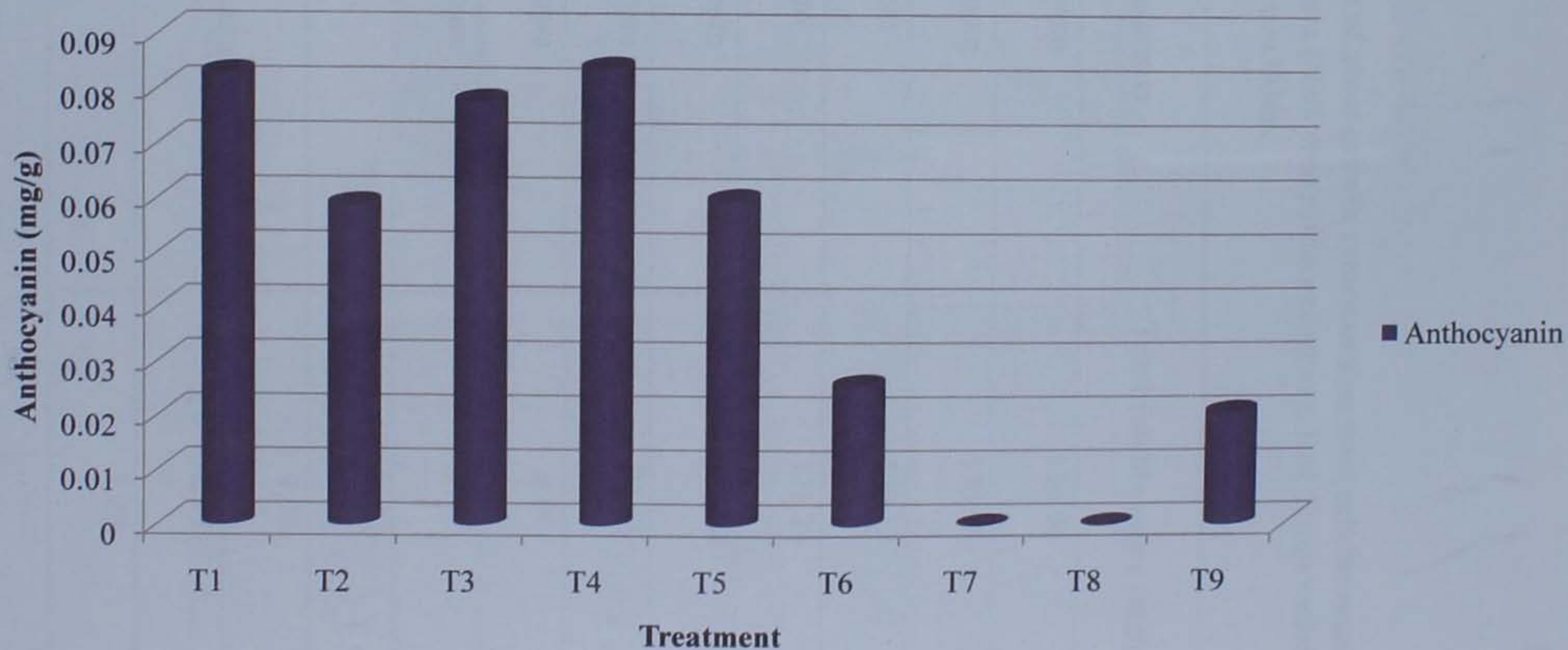
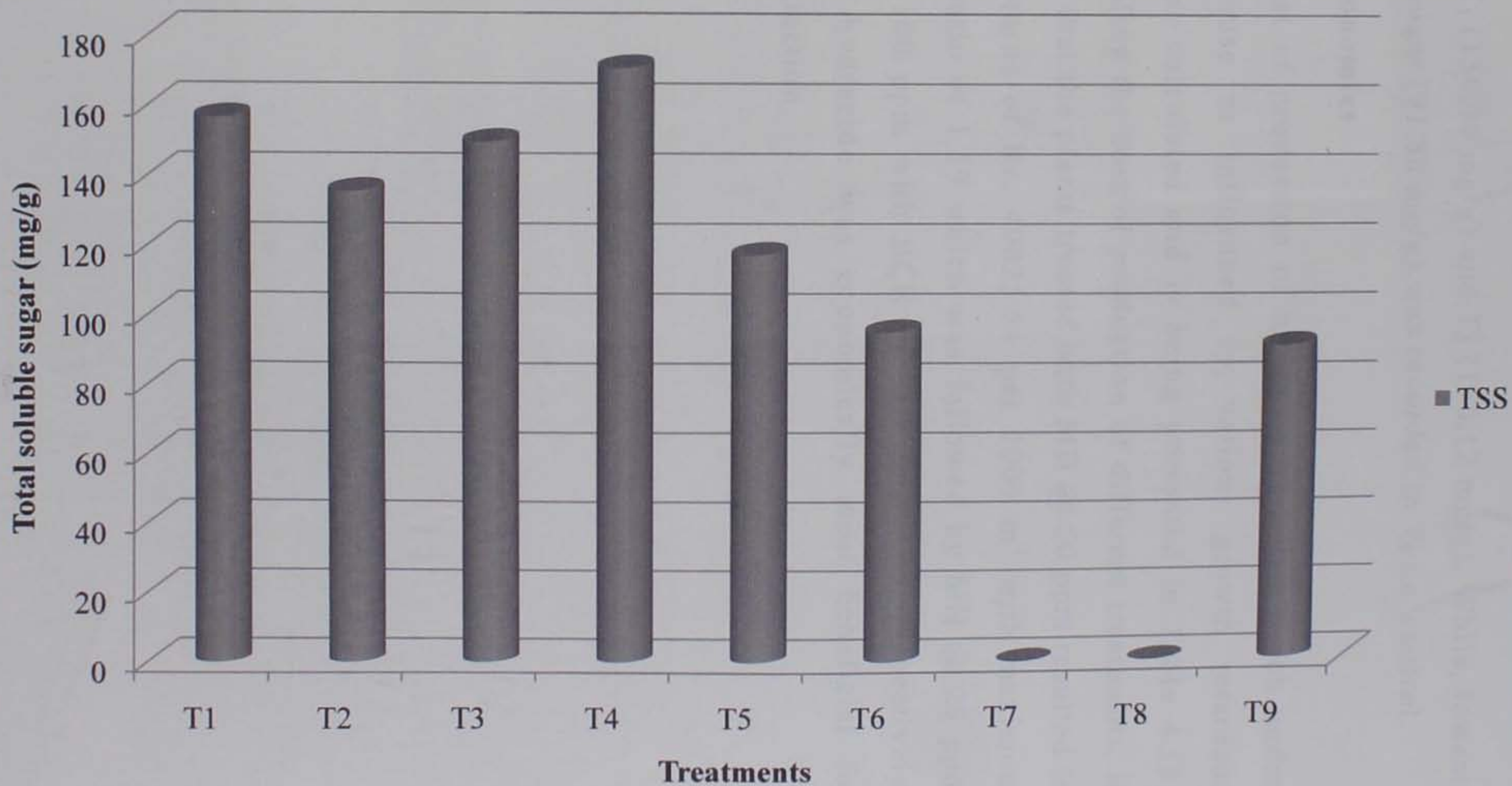


Table 4.17: Effect of plant growth retardants on total soluble sugar of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.

| Treatments | Total soluble sugar (mg/g) |
|--------------------------------|----------------------------|
| T ₁ – CCC @ 100 ppm | 156.96 |
| T ₂ – CCC @ 200 ppm | 135.96 |
| T ₃ – MH @ 25 ppm | 150.12 |
| T ₄ – MH @ 50 ppm | 171.24 |
| T ₅ – TIBA @ 15 ppm | 117.84 |
| T ₆ – TIBA @ 30 ppm | 95.64 |
| T ₇ – PCB @ 150 ppm | 0.00 |
| T ₈ – PCB @ 300 ppm | 0.00 |
| T ₉ – Control | 91.80 |
| S.Em.± | 0.99 |
| C.D. at 5 % | 2.99 |
| C.V.% | 1.69 |

Fig. 4.17 : Effect of plant growth retardants on total soluble sugar (mg/g) of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 % shade condition.



followed by T₁ (156.96 mg/g) and T₃ (150.12 mg/g). While, lowest total soluble sugar (91.80 mg/g) was recorded in T₉ i.e. control.

4.5 Economics

Cost of production of heliconia var. Red Torch under shade net house as influenced by various growth retardant treatments was calculated and is being presented in Table 4.18. While, evaluating the cost of production of different treatments, it was observed that the plants treated with MH @ 50 ppm resulted in higher net returns of Rs. 49025.51 per 1000 m² with maximum benefit cost ratio of 1.19 which was followed by MH @ 25 ppm and CCC @ 100 ppm with BCR of 1.02 and 0.95, respectively. Thus maleic hydrazide was economically most beneficial for heliconia production.

Table-4.18: Economics of heliconia var. Red Torch spikes and suckers as influenced by various treatments.

| Treatments | Spikes production (No.) | Spikes return (Rs.) | Suckers production (No.) | Suckers return (Rs.) | Common Cost (Rs. per 1000 m ²) | Treatment cost (Rs. per 1000 m ²) | Total cost (Rs. per 1000 m ²) | Gross return (Rs. per 1000 m ²) | Net return (Rs. per 1000 m ²) | BCR |
|----------------|-------------------------|---------------------|--------------------------|----------------------|--|---|---|---|---|-------|
| T ₁ | 4895.83 | 29374.98 | 18489.58 | 55468.74 | 40884 | 2625 | 43509 | 84843.72 | 41334.72 | 0.95 |
| T ₂ | 4270.83 | 25624.98 | 16614.58 | 49843.74 | 40884 | 5250 | 46134 | 75468.72 | 29334.72 | 0.64 |
| T ₃ | 4635.41 | 27812.46 | 18385.42 | 55156.26 | 40884 | 201 | 41085 | 82968.72 | 41883.72 | 1.02 |
| T ₄ | 5572.92 | 33437.52 | 18958.33 | 56874.99 | 40884 | 403 | 41287 | 90312.51 | 49025.51 | 1.19 |
| T ₅ | 3541.67 | 21250.02 | 15156.25 | 45468.75 | 40884 | 9855 | 50739 | 66718.77 | 15979.77 | 0.31 |
| T ₆ | 3333.33 | 19999.98 | 15625.00 | 46875.00 | 40884 | 19710 | 60594 | 66874.98 | 6280.98 | 0.10 |
| T ₇ | 0.00 | 0.00 | 7708.33 | 23124.99 | 40884 | 3557 | 44441 | 23124.99 | -21316.01 | -0.48 |
| T ₈ | 0.00 | 0.00 | 8541.67 | 25625.01 | 40884 | 7115 | 47999 | 25625.01 | -22373.99 | -0.47 |
| T ₉ | 2968.75 | 17812.5 | 13072.92 | 39218.76 | 40884 | ... | 40884 | 57031.26 | 16147.26 | 0.39 |

Cost of plant growth retardants :

Maleic hydrazide (98 %) - Rs. 215 per 100 g

Cycocel (50 %) – Rs. 700 per 100 ml

Tri iodo benzoic acid (97 %) – Rs. 876 per 5 g

Pclobutrazol (25 %) – Rs. 6325 per litre

Selling price:-

Heliconia spikes – Rs. 6 per spike

Suckers – Rs. 3 per sucker



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Dr. A.R. Pathak, Honb'le Vice Chancellor, NAU, Navsari**



**Padma Bhushan Dr. R.B. Singh, President, NAAS, New
Delhi , Ex-ADG, FAO, United Nation**

Plate - VI : Visit of dignitaries at experiment



DISCUSSION

V. DISCUSSION

Heliconia is one of the high value flower crop being cultivated in some parts of southern India. It is widely used for cut flower crop and as popular landscape plant for its attractive foliage and brilliant flower spikes in tropical and subtropical areas. Among the different cultivation practices, regulation of growth by use of plant growth retardants has great influence on yield and quality of heliconia flowers.

Despite its probability as high value flower crops in market, it suffers from one major drawback that it requires more days for flower production as compared to other flower crops.

Taking this point into consideration, the present study on "Effect of plant growth retardants on growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 per cent shade net condition." was carried out during the year 2012-2013. The effect of plant growth retardants was recorded and the results obtained are discussed in this chapter. The attempt in this chapter is to assign the reasons for the changes affected in this chapter in growth, flowering and yield attributes due to imposition of different treatments and to corroborate these with the findings of earlier workers from the literature in order to understand the effect of cause relationship.

The treatments have been discussed under the following subheads:

- 5.1 Effect on vegetative growth
- 5.2 Effect on flowering and yield

5.3 Effect on pigments

5.4 Economics

5.1 Effect on vegetative growth

It is perceptible from the data that various plant growth retardants with different concentrations significantly influenced vegetative characteristics viz. plant height, number of leaves per plant and suckers per clump at 3, 6, 9 and 12 MAP, while leaf area at 12 MAP (Table 4.1 to 4.4). Since, uniform sized sprouted rhizomes (suckers) were planted in all plots, however all differences in vegetative characters were seen due to various treatments.

Among the various treatments, minimum plant height (24.86 cm, 25.95 cm, 27.20 cm and 49.60 cm) was recorded with the drenching of paclobutrazol @ 300 ppm i.e. T₈, which was at par with paclobutrazol @ 150 ppm i.e. T₇ (25.73 cm, 26.76 cm, 28.40 cm and 54.33 cm) followed by TIBA @ 30 ppm i.e. T₆ (59.53 cm, 103.15 cm, 133.46 cm and 140.26 cm) at 3, 6, 9 and 12 MAP, respectively. Whereas, maximum plant height was found in control i.e. T₉, which was on par with T₃, T₂ and T₁ (at 3 and 9 MAP), T₃, T₁, T₆ and T₅ (at 6 MAP) and T₅, T₃, T₂ and T₁ (at 12 MAP).

Plant height of heliconia was varied significantly due to application of different growth retardants with different concentrations. Generally, retardants suppress the growth of plant after application and carry towards reproductive phase early. The plants which were treated with paclobutrazol showed drastically

reduction in growth during experiment. The height of the plants treated with the treatments T₇ and T₈ was almost same at 3rd, 6th and 9th months after planting, whereas it showed slight increase in height at 12th MAP.

Plant height can be influenced by type and concentration of growth retardants (Daniel, 1986). The difference in plant height with the type and concentration of growth retardants may be due to their different mode of action in inhibiting plant growth regulators particularly gibberellins and auxins as explained by Warner and Erwin (2003). At low concentrations, growth retardants typically reduce cell elongation, whereas at high concentrations the reduction is increased due to a retard cell division (Grossman, 1992). The drastically retarded growth with application of paclobutrazol @ 150 and 300 ppm may be due to its very high concentrations, which has more inhibitory role on cell division and cell elongation of apical meristematic cells and also on gibberellins synthesis. Similar results were found in annual carnation (Foley and Keever, 1991) and marigold (Latimmer, 1991) when plants treated with paclobutrazol.

Growth reduction in plants when treated with TIBA @ 30 ppm may be due to antiauxin activity, disturbed carbohydrate metabolism, inhibition of cell division and elongation of apical meristem.

Sometimes at 12 MAP, plant height was lower than 9 MAP because heliconia was peak in blooming at 9 MAP and

flowers were cut along with plant stems while height of largest plant from clump was measured so it may be lower than earlier.

Maximum number of leaves per plant were recorded with the application of MH @ 50 ppm (T₄), which was on par with treatments T₁ (CCC @ 100 ppm), T₃ (MH @ 25 ppm), T₂ (CCC @ 200 ppm) and T₆ (TIBA @ 30 ppm) at 3 and 12 MAP. Whereas, the highest in number of leaves were also found with same treatment i.e. T₄, which was statistically at par with T₁ (CCC @ 100 ppm), T₃ (MH @ 50 ppm), T₂ (CCC @ 200 ppm), T₆ (TIBA @ 30 ppm) and T₅ (TIBA @ 15 ppm) at 6 and 9 MAP.

The increase in number of leaves per plant may be related to diversion of photosynthates towards the axillary buds and reduction in shoot growth and inhibition of apical dominance caused by auxin (Gnyandev, 2006). The increase in number of leaves due to maleic hydrazide had supportive evidence from the findings of Venkatesan *et al.* (2004) in crossandra and Navale *et al.* (2010) in chrysanthemum.

The highest number of suckers per plant at 6, and 12 MAP were recorded with treatment T₄ (MH @ 50 ppm), which was on par with treatments T₁, T₃, T₂ and T₆ (at 6 MAP) while T₁ and T₃ were also at par with T₄ at 9 MAP. Increase in number of suckers per clump may be due to the inhibition of terminal growth and stimulation of the growth of apical meristematic cells, which would have triggered the reproductive shoots.

Leaf area of plant is considered as a lungs of the plants and it is a very important character because it has direct

connection with interception of light and photosynthesis and ultimately with overall growth and development. Regarding leaf area, it was significantly influenced and found maximum in T₄ (MH @ 50 ppm) which was at par with T₁ (CCC @ 100 ppm) and T₃ (MH @ 25 ppm). Development of maximum leaf area might be due to emergence and exploitation of leaves which is pivotal for overall growth and development in plant and may also be due to inhibition of gibberellins synthesis, which stimulates maximum leaf expansion. Similar results were found in crossandra (Venkatesan *et al.*, 2004) and dahlia (Khan and Tewari, 2003).

5.2 Effect on flowering and yield

Regarding the effect of various growth retardant treatments, it was observed that flowering parameters *viz.* days to flowering, flowering duration, number of bracts, number of florets per bract, rachis length, stalk length, number of spikes per clump, number of spikes per plot and 1000 m² were significantly influenced, except paclobutrazol. Moreover, overall presentability also influenced (Table 4.5 to 4.14).

Heliconia plants take more time to flower as compared to other flower crops; therefore, it is one of the major limiting factor for expanding cultivation area in country for this high value flower crop. In this connection, retardants can play key role with respect to early flowering as well as qualitative and quantitative parameters.

Application of maleic hydrazide @ 50 ppm decreased days to flowering (147.20), which was on par with T₁, T₃ and T₂

treatments. These results were in close agreement with Dutta *et al.* (1993) in chrysanthemum and Kumar and Kumar (2004) in balsam.

These results may be due to the fact that plants treated with maleic hydrazide have built up sufficient food reserves at initial stages due to suppression of apical dominance, increased number of leaves and mobility of photosynthates from source to sink. This reserve food has been utilized for reproductive purpose with a restriction on vegetative growth which decreases days to flowering.

Heliconia produce brilliant flowering spikes which are most attractive and showy part of plant therefore its longevity is very important parameter. Flowering duration or longevity of spike *in situ* was extended significantly over control by growth retardant treatments. The longest duration of spike (55.40 days) was registered by the application of maleic hydrazide @ 50 ppm (T₄) which was reported at par with T₁ (cycocel @ 100 ppm) and T₃ (MH @ 25 ppm) treatments. The result of the present study was in agreement with the findings in nerium (Anburani and Ananth, 2008) and chrysanthemum (Dutta *et al.*, 1993).

Application of maleic hydrazide and cycocel enhance the chlorophyll content of leaves which helps to increase the functional life of the source for a longer period leading to improve partitioning efficiency and productivity (Kashid *et al.*, 2010). They also improved the longevity by maintaining the level of chlorophyll, protein and RNA content of leaf at higher level for a longer duration and suppress the senescence (Kar *et al.*, 1989).

Increasing number of bracts (4.60) was found in MH @ 50 ppm which was at par with T₁, T₃, T₂ and T₅ treatments. Whereas, maximum number of florets was also found with the application of MH @ 50 ppm (12.06) which was followed by CCC @ 100 ppm i.e. T₁ (11.53), MH @ 25 ppm i.e. T₃ (11.27) and CCC @ 200 ppm i.e. T₂ (10.66) treatments.

Growth retardants work on important principle i.e. source to sink relationship and the translocation of photosynthates towards sink (Kashid *et al.*, 2010). The plants treated with maleic hydrazide and cycocel have built up sufficient food reserves due to reduction in plant height with increasing number of leaves which resulted in higher production of photosynthates. The quick mobilization of these photosynthates from leaves (source) to flowers (sink) increases number of bracts per spike and florets per bracts (Joshi and Reddy, 2006).

The maximum rachis length (15.41 cm) with longest stalk (110.98 cm) was found with the application of MH @ 50 ppm. This result was on par with T₁, T₃, T₂, T₅ and T₆ in case of rachis length, whereas stalk length was at par with T₁ treatment. It showed a trend of progressive increase with increased levels of the retardants. Similar results were found with cycocel and maleic hydrazide in chrysanthemum by Dutta *et al.* (1993) and Kumar and Kumar (2004) in balsam.

Enhancement of rachis and stalk length might be due to increase in the number of bracts. This enlargement is caused by drawing of photosynthates to the flower as a consequence of

intensification of the sink. Further, other scientists have reported suppression in vegetative parameters with the application of growth retardants but not on flowering parameters (Lee and Suh, 2005; Anburani and Ananth, 2008; Saikia and Talukdar, 1998; Kazaz *et al.*, 2010 and Khan and Tewari, 2003).

Yield is the functional result of growth parameters of the plant like plant height, number of leaves and number of suckers. It is also very important attribute which attract attention of farmers for commercial cultivation. The results of the present investigation indicated that number of spikes per clump, per plot and 1000 m² (4.46, 35.66 and 5572.92, respectively) were significantly higher with the application of MH @ 50 ppm (T₄), followed by CCC @ 100 ppm (T₁) (3.93, 31.33 and 4895.83, respectively).

These results were in line with those of Anburani and Ananth (2008) in nerium, they observed higher yield per hectare in maleic hydrazide as compared to control and other treatments.

This might be due to the suppression of apical dominance resulted in increasing number of leaves per plant, leaf area and number of suckers per clump which ultimately increased number of flowers per plant. It was also due to increased mobilization of biomass to flowers from sources in leaves.

The yield was also appreciably increased by CCC @ 100 ppm. The increased yield by cycocel resulted in to known effect of this retardant on flower crops *viz.* in jasmine (Sridhar, 2006) and African marigold (Sunitha, 2006).

Further, growth retardants are known to influence the source to sink relationship and stimulating the translocation of photosynthates towards sink (Kashid *et al.*, 2010). Kumar *et al.* (2012) also found beneficial effect of growth retardants in salvia compared to growth promoters in terms of the translocation of photo-assimilates towards developing reproductive parts which is responsible for higher yield .

The best quality of flower on the basis of visual analysis was observed in heliconia var. Red Torch with application of MH @ 50 ppm, this treatment got the highest score (10.0) and followed by CCC @ 100 ppm (9.0). It was due to the maximum number of bracts, rachis length, stalk length and its bright appearance.

Application of maleic hydrazide @ 50 ppm also recorded maximum vase life (13.33 days). It might be due to reduced physiological weight loss. Restricted respiration due to inhibitory action of growth retardants might have increased the vase life. It may also be due to the maximum number of bracts, florets and longest stalk. Similar findings were also obtained by Dutta *et al.* (1993) and Talukdar and Paswan (1997) in chrysanthemum.

5.3 Effect on pigments

Concerning the effect of various growth retardant treatments, it was observed that chemical parameters *viz.* anthocyanin, chlorophyll and total soluble sugar were significantly influenced (Table 4.15 to 4.17).

Chlorophyll content of the leaves play a vital role in photosynthesis process for making the food as discussed earlier. Maximum chlorophyll content (0.139 mg/g) in leaf was recorded with the application of MH @ 50 ppm which was followed by CCC @ 100 ppm (0.118 mg/g) and MH @ 25 ppm (0.106 mg/g). This finding is in conformity with that of Cathey (1964) who opined that growth retardants in addition to the inhibition of cell division caused induction of grana and initiated the development of chloroplasts.

Anthocyanin is the major flower pigment in higher plants. In most cases, anthocyanin accumulation is an integral part of flower development and the processes of bracts pigmentation. In present study, it was found that MH @ 50 ppm showed maximum anthocyanin content (0.084 mg/g), which was at par with T₁ treatment (0.083 mg/g). Pigment content was improved with high concentration of growth retardants in bracts of poinsettia (Lodeta *et al.*, 2010). This can be attributed to improve sustained bract cellular component as indicated to enhance flower longevity.

Total soluble sugar was also increased in the flowers treated with MH @ 50 ppm (171.24 mg/g) which was followed by CCC @ 100 ppm (156.96 mg/g) and MH @ 25 ppm (150.12 mg/g).

5.4 Economics

Economics is the main deliberation which helps in taking a decision regarding the adoption of a new technology. The net income in rupees per 1000 m² was worked out from number of

flowers and suckers produced by considering their average price and the inputs used during the period of experimentation.

From the study, it is apparent (Table 4.18) that the highest net return (Rs. 49025.51 per 1000 m²) was recorded under treatment T₄ i.e. MH @ 50 ppm and followed by MH @ 25 ppm i.e. T₃ (Rs. 41883.72 per 1000 m²), CCC @ 100 ppm i.e. T₁ (41334.72 per 1000 m²) and CCC @ 200 ppm i.e. T₂ (Rs. 29334.72 per 1000 m²).

With respect to BCR, the treatment T₄ (MH @ 50 ppm) gave the highest BCR (1.19) and it was closely followed by MH @ 25 ppm i.e. T₃ (1.02), CCC @ 100 ppm i.e. T₁ (0.95) and CCC @ 200 ppm i.e. T₂ (0.64). These results clearly indicated that the growth retardants MH and CCC were economically most beneficial for heliconia production.

Moreover, heliconia is an herbaceous perennial plant which requires investment at 1st year only after that it entails maintenance. Flowering yield of heliconia continuously increases in the 2nd and 3rd year as more number of suckers are developed per plant which is economically very beneficial.



SUMMARY

&

CONCLUSION

VI. SUMMARY AND CONCLUSION

The present study entitled "Effect of plant growth retardants on growth, flowering and yield of heliconia (*Heliconia psittacorum*) var. Red Torch under 50 per cent shade net condition." was carried out during the year 2012-2013. There were 9 treatments namely T₁-CCC @ 100 ppm, T₂-CCC @ 200 ppm, T₃-MH @ 25 ppm, T₄-MH @ 50 ppm, T₅-TIBA @ 15 ppm, T₆-TIBA @ 30 ppm, T₇-PCB @ 150 ppm, T₈-PCB @ 300 ppm, T₉-Control were tested in Randomized Block Design with three replications. This experiment was conducted at Floriculture Research Farm, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during 2012-2013.

The weather condition was favorable for plant growth and there was no serious attack of pest and diseases during the course of investigation.

The various observations on growth, yield and flowering attributes of heliconia were recorded to evaluate the efficiency of different growth retardant treatments. Important findings emerged out from this investigation are summarized here.

6.1 Effect on vegetative growth

The minimum plant height at 3, 6, 9 and 12 MAP was recorded in T₈ (paclobutrazol @ 300 ppm) treatment which was at par with T₇ (paclobutrazol @ 150 ppm) and followed by T₅ (TIBA @ 15 ppm).

At all intervals maximum number of leaves per plant was found with the application of MH @ 50 ppm (T₄) which was at par with T₁, T₃, T₂, and T₆ treatments at 3 and 12 MAP whereas T₁, T₃, T₂, T₅ and T₆ at 6 and 9 MAP.

Significantly higher number of suckers was observed with the application of MH @ 50 ppm (T₄) at 6, 9 and 12 MAP. This treatment was on par with T₁ and T₃, T₂ and T₆ at 6 MAP. Whereas, at 9 and 12 MAP, it was at par with T₁, T₃ at 9 MAP and T₁, T₃ and T₂ (at 12 MAP).

At 12 MAP, the maximum leaf area was noted in MH @ 50 ppm (T₄) which was statistically at par with CCC @ 100 ppm (T₁) and MH @ 25 ppm (T₃).

6.2 Effect on flowering and yield

All plant growth retardants influenced flowering and yield of heliconia, except paclobutrazol @ 150 and 300 ppm due to its high concentration which didn't produce flowers.

As far as, least days to flower was found in plants treated with MH @ 50 ppm which was at par with T₁, T₃, and T₂, treatments, whereas maximum days to flower was recorded in control (T₉) treatment.

Among the all treatments, MH @ 50 ppm treated plants recorded maximum flowering duration of spike *in situ* which was at par with T₁ and T₃.

The maximum number of bracts per flower was observed in T₄ (MH @ 50 ppm) which was statistically on par with T₁, T₃, T₂ T₅ treatments. While minimum number of bracts per flower was found in control (T₉).

Regarding number of florets, the maximum number of florets per bract was significantly higher with the application of MH @ 50 ppm (T₄) which was at par with CCC @ 100 ppm (T₁), MH @ 25 ppm (T₃) and CCC @ 200 ppm while minimum number of florets was found in control (T₉).

Maximum rachis length was measured in T₄ (MH @ 25 ppm) treatment which was at par with T₁, T₃, T₂, T₅ and T₆ while it was found minimum in control (T₉).

In case of stalk length, the highest length was found with the application of MH @ 50 ppm, which was significantly at par with T₁ (CCC @ 100 ppm) treatment, whereas lowest stalk length was recorded in control (T₉).

The higher number of spikes per clump per year were observed in T₄ i.e. MH @ 50 ppm which was followed by CCC @ 100 ppm (T₁). T₄ was also recorded maximum in number of spikes per plot and per 1000 m² followed by T₁.

The overall presentability of heliconia spike was found maximum in maleic hydrazide @ 50 ppm which was followed by CCC @ 100 ppm i.e. T₁.

Application of MH @ 50 ppm was proved better than other treatments for maximizing vase life of heliconia spike. This was at par with treatments T₁ and T₃, whereas minimum vase life was found in control.

6.3 Effect on pigments

Maximum chlorophyll content was noticed in T₄ (MH @ 50 ppm), followed by T₁, T₃ and T₂, while the lowest chlorophyll content was observed in control.

Along with all treatments, maximum anthocyanin was found with treatment T₄ (MH @ 50 ppm) which was at par with T₁, whereas minimum anthocyanin was found in control.

Maximum total soluble sugar was found in plants treated with MH @ 50 ppm which was followed by T₁, T₃ and T₂ while minimum value was recorded in T₉ treatment i.e. control.

6.4 Economics

As per economic point of view, MH @ 50 ppm i.e. T₄ was found better as compared to other treatments. T₄ recorded the highest net income of Rs. 49025.5 per 1000 m² along with maximum BCR of 1.19, which was followed by MH @ 25 ppm (T₃) and CCC @ 100 ppm (T₁).

CONCLUSION :

In general, all growth retardant treatments improved the vegetative growth as well as flowering of heliconia plant except plants treated with paclobutrazol @ 150 and 300 ppm. By gradual

analysis of these findings, it can be recommended that application of MH @ 50 ppm proved to be the best treatment for obtaining higher yield of good quality flowers which was followed by the CCC @ 100 ppm and MH @ 25 ppm.

Future line of research work

Best on the present investigation, the following suggestions are made for future line of work in heliconia with respect to growth retardants.

1. Further trial should be conducted on lower concentration of paclobutazol because 150 and 300 ppm clearly showed drastic reduction on vegetative parameters and also didn't produce flowers up to one year.
2. These growth retardants, specially paclobutrazol can also be tried on tall species of heliconia.
3. The study should be carried out to know the effect of spray of different growth retardants on heliconia plant.



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(* Original not seen)



APPENDIX

Appendix-I: Meteorological parameters recorded during the growth and development of heliconia (*Heliconia psittacorum*) var. Red Torch (monthly mean).

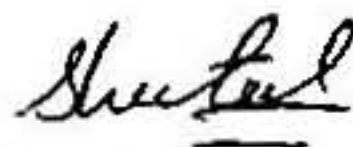
| Month and Year | Temperature (°C) | | Relative Humidity (%) | | Rainfall (mm) |
|----------------|---------------------|-------|--------------------------|-------|------------------|
| | Max | Min | Max. | Min. | |
| March 2012 | 34.83 | 16.54 | 78.66 | 28.26 | 0 |
| April 2012 | 35.81 | 23.03 | 85.01 | 41.58 | 0 |
| May 2012 | 33.90 | 26.19 | 80.37 | 56.94 | 6 |
| June 2012 | 33.34 | 27.16 | 84.41 | 68.14 | 155 |
| July 2012 | 30.70 | 26.32 | 92.14 | 83.21 | 271 |
| August 2012 | 29.98 | 25.60 | 92.40 | 82.49 | 200 |
| September 2012 | 30.20 | 24.53 | 92.95 | 76.02 | 618 |
| October 2012 | 34.91 | 22.08 | 80.03 | 46.60 | 12 |
| November 2012 | 33.25 | 16.20 | 72.77 | 31.47 | 0.0 |
| December 2012 | 31.79 | 16.37 | 71.92 | 33.63 | 0.0 |
| January 2013 | 29.7 | 12.3 | 81.6 | 40.5 | 0.0 |
| February 2013 | 31.7 | 16 | 74.8 | 28.4 | 0.0 |

CERTIFICATE

This is to certify that, I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process if necessary for rendering reference service in a library or documentation centre.

Place: Navsari

Date : 13/05/2013


(Jadhav Sheetalben)