EFFECT OF GROWTH REGULATORS ON GROWTH, FLOWERING AND YIELD OF CROSSANDRA (*Crossandra undulaefolia* Salisb.*)* GENOTYPE ACC-1

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C E R T I F I C A T E

This is to certify that the thesis entitled **"EFFECT OF GROWTH REGULATORS ON GROWTH, FLOWERING AND YIELD OF CROSSANDRA (*Crossandra undulaefolia* Salisb.) GENOTYPE ACC-1"** submitted by Mr. A**RABANNA PUJERI** bearing **ID No. UHS14PGM419** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FLORICULTURE AND LANDSCAPE ARCHITECTURE** University of Horticultural Sciences, Bagalkot is a record of research work carried out by him during the period of his study in this university under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Arabhavi

Date: August, 2016

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JULY, 2016 ***(ARABANNA PUJERI)***

Affectionately dedicated to

My teachers,parents and brothers

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1. INTRODUCTION

Crossandra is an important commercial crop grown mainly in India, Tropical Africa and Madagascar (Bailey, 1963). Crossandra is an important loose flower in South India and commercially grown to an extent of 4,000 ha in Karnataka, Tamil Nadu and Andhra Pradesh (Bhattacharjee, 2006) which was increased to 4700 ha during 2014-15 (Anon., 2014).

Crossandra belongs to the family Acanthaceae. There are around 50 species but only a few species like *Crossandra undulaefolia* Salisb. (Syn: *Crossandra infundibuliformis* (L.) Nees.), *Crossandra mucronata* and *Crossandra sebacaulis* are cultivated. The species grown for commercial flower production is *Crossandra undulaefolia* Salisb.

Crossandra is a perennial evergreen herb or under-shrub in habitat. It grows to about 3 feet height, with upright growth habit. The leaves are toothed, verticillate hairy or glabrous. The flowers are non-fragrant. The inflorescence is a dense sessile spike with predominant bracts. The scarlet orange flowers are borne on four sided spikes; stamens are four in number, capsule is oblong, acute and contains four seeds.

Two types of crossandra commercially cultivated, they are: (i) Orange Crossandra (2n=40), a tetraploid which sets seeds profusely, breeds true to type and produces bright orange coloured flowers and (ii) Delhi crossandra, triploid (2n=30) which produces more attractive flowers of bright deep orange colour and is propagated through stem cuttings.

In recent years, the use of growth regulators in floriculture crop production has undergone enormous change to enhance the yield. These plant growth regulators play an important role in plant growth modification and development process. Although, endogenous growth substances normally regulate the plant growth, exogenous application of plant growth substances bring out modification in growth and development. They are known to bring various changes in plants. These in minute concentrations can dramatically change the plants vegetative and reproductive

parameters. Growth promoters not only alter the growth parameters, advance blooming, promotes flowering in many ornamental plants but also extend the shelf-life of many cut flowers. These growth substances improve the physiological efficiency of the plants by regulating the rate of photosynthesis, transpiration, photorespiration, water and nutrient uptake, leaf senescence and by imparting resistance to environmental stresses and ultimately increasing the harvest index. It is generally accepted that exogenously applied growth substances show their effects through the alteration in the levels of naturally occurring hormones and it varies with their concentrations used, method of application and frequency of application on plants, species, varieties and various other factors which influence the absorption and translocation of the chemicals, thus modifying the growth and development of plants.

The flowers of crossandra are commercially used for garlands making, as hair adornment and performing religious and ceremonial functions. Though the flowers are non-fragrant, they are very popular because of their attractive bright colour, light weight likewise the flowers are especially valued for making garlands, either alone or in combination with jasmine flowers.

The commercial cultivation of crossandra depends on many factors like climatic condition, fertilizer application, spacing, etc. Among them application of growth regulators is also one of the important factor to get higher yield. So, there is need to study the effect of growth regulators on growth and yield of crossandra.

The commercial field growing crossandra thrives well under mild tropical climatic conditions with cultural operations like proper spacing and application of proper dosage of manures and fertilizers. Hence, the proposed research programme helps the farmers in choosing specific concentration of growth regulator on ACC-1 to increase flower yield.

Objectives

1. To study the effect of growth regulators on growth and flowering of crossandra genotype ACC-1.
2. To study the effect of growth regulators on floral longevity and yield of crossandra genotype ACC-1.
3. Estimation of economics for growth regulators application in crossandra genotype ACC-1.

2. REVIEW OF LITERATURE

Crossandra is one of the easiest grown perennial flowers and has wider adaptability to different soil and climatic conditions. The plants with their attractive flower colour, bloom for a considerably long period. All these factors have made crossandra as one of the most popular perennial flowers in India, for garden display as well as for commercial cultivation. The information on effect of plant growth regulators on growth, flowering and yield of crossandra is very limited. Hence, literature on closely related crops like marigold (*Tagetes* spp.), China aster (*Callistephus chinensis* L. Nees), chrysanthemum (*Chrysanthemum morifolium*) and other crops has been reviewed and presented in this chapter.

2.1 Effect of plant growth regulators

In recent years, the use of growth regulators in floriculture crop production has undergone enormous change to enhance the yield and these plays an important role by modifying the plant growth and development process. These growth substances improve the physiological efficiency of the plants by regulating the rate of photosynthesis, transpiration, photorespiration, water and nutrient uptake, leaf senescence and by imparting resistance to environmental stresses and ultimately increasing the harvest index. It is generally accepted that exogenously applied growth substances produce their effects through the alteration in the levels of naturally occurring hormones and it varies with their concentrations used, method of application, frequency of application on plants, species, varieties and various other factors which influence the absorption and translocation of these chemicals, thus modifying the growth and development of plants.

2.1.1 Gibberellic acid (GA_3)

Gibberellins are chemically tetracyclic diterpenoids that act at all stages in the plant life cycle, which display a remarkable diversity of physiological processes of plants including stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction and leaf and fruit senescence, flowering, and quality of horticulture produce. This large group of phyto harmones with 136 different compounds from GA_1 to GA_{136}, commonly occurs in plant and fungus as well as in bacteria. All Gibberellins are derived from ent- gibberellane skeleton, but are synthesized via kaurene (Sakamoto *et al.*, 2004). Kohl and Kofranek (1957) were among the first to investigate the possible use of GA_3 in floriculture crops.

2.1.1.1 Effect of gibberellic acid

Effect of GA3 on growth, flowering, quality and yield parameters

Crossandra

Binisundar *et al.* (2008) studied the effect of growth regulators on growth and flowering in triploid crossandra. All the growth regulators have shown significant effect. Among the treatments, GA_3 @ 200 ppm recorded the maximum flower yield (3191.8 kg/ha) followed by NAA @ 150 ppm (2730.1kg/ha) and in case of different concentrations of BA @ 200 ppm resulted in maximum yield (2950.6 kg/ha). This shows that all the three growth regulators have beneficial effect on growth and yield.

Marigold

Girwani *et al.* (1990) studied the effect of GA_3 (50 or 100 ppm), CCC (500 or 1000 ppm) and Zn (0.2 or 0.4 % Zn $S0_4$) on 30 days old seedlings of African marigold (*Tagetes erecta*) cv. African Giant. Highest dry weight of flowers (68.20 g/plant) and number of flowers per plant (37.10) were obtained at 1000 ppm CCC. All the treatments reduced the number of days taken to flowering as compared with the control (67.30 days), CCC at 1000 ppm was most effective (47.30 days). GA_3 at 100 ppm gave the largest flower diameter (5.8 cm).

Singh *et al.* (1991) obtained maximum plant height (54.09 cm), number of branches per plant (10.43), flower yield per plant (574.55 g), number of flowers per plant (56.00), flower weight, thousand seed weight and duration of flowering by spraying of GA_3 at 200 ppm in African marigold (*Tagetes erecta* L.).

Rajesh (1995) reported that, foliar spray of GA_3 at 50-500 ppm in calendula significantly increased the plant height, number of branches, number of leaves, and more number of flowers per plant (23.88) and also increased the total dry weight of the plant (28.55 g) as compared to control.

Spraying of GA_3 at 200 ppm resulted in maximum plant height (59.77 cm), dry weight of 30 leaves (2.57 g), number of seeds per flower (96.43), seed weight per flower (0.38 g), seed weight (0.41 g) and seed yield per plant (63.41 g) in French marigold (Singh, 2004).

Verma and Arha (2004) revealed that foliar application of GA_3 at 200 ppm resulted in more number of flowers per plant (36.25), yield of flowers per plant (82.62 g) in African marigold.

Tyagi and Vijaykumar (2006) studied the effect of GA_3 in African marigold and reported that GA_3 @ 200 ppm application recorded maximum plant height (22.25 cm), primary branches per plant (15.49), flowers per plant (14.00), weight of flowers per plant (86.31 g) and yield of flowers (71.92 q/ha).

Azzaz *et al.* (2007) reported that foliar spray of GA_3 at 150 ppm recorded highest plant height (52.43 cm), dry weight of plant (104.28 g), early flowering (85.56 days), number of flowers per plant (22.08), dry weight of flower (2.08 g), chlorophyll content (3.51 mg/g) and carotene (0.79 mg/g) in pot marigold (*Calendula officinalis* L.).

Sunitha *et al*. (2007) revealed that pinching and spraying of GA_3 at 200 ppm recorded significantly highest plant height (101.20 cm), number of primary branches (14.40), number of flowers per plant (68.8), seed yield per plant and per hectare (20.6 g and 531.5 kg, respectively), 1000 seed weight (3.3 g), root length (6.30 cm), shoot length (5.40 cm) and seedling dry weight (11.40 mg) in African marigold.

Swaroop *et al.* (2007) studied the influence of different growth regulators on vegetative growth, flowering and seed characters of African marigold cv. Pusa Narangi Gainda during early winter. The result revealed that application of GA_3 at 300 ppm recorded maximum plant height (89.50 cm), number of branches per plant (8.75), number of flowers per plant (23.75), fresh weight of flower (6.92 g), yield per plant (433.00 g) and seed yield per plant (23.50 g).

Ramdevaputra *et al.* (2009) reported that spraying of GA_3 at 300 ppm showed maximum plant height at first flower initiation and full bloom stage (57.37 and 63.83 cm, respectively), plant spread at flower initiation and full bloom stage (49.66 and 53.95 cm^2, respectively), fresh weight of plant (375.85 g), highest flower diameter (6.39 cm) and maximum vase life (7.46 days). While maximum number of branches per plant (13.62) and maximum flowering span (64.17 days) was observed in treatment with 200 ppm GA_3 in African marigold.

Amit *et al*. (2011) reported maximum plant height (43.78 cm and 66.96 cm in 45 and 90 DAT respectively), maximum number of flowers per plant (28.15) and fresh weight of flowers (12.45 g) in spraying of GA_3 350 ppm in African marigold cv. Pusa Narangi Gainda.

Amit Kumar *et al.* (2012) have reported the effect of plant growth regulators on growth, flowering and yield of African marigold cv. Pusa Narangi Gainda. They observed that application of gibberellic acid at 350 ppm was best treatment in all respect as it enhanced vegetative grow than and flower yield. Further, cycocel at 2000 ppm was also beneficial as it increased flower yield and reduced vegetative growth without affecting initiation of flower bud and commencement of flowering.

Mithileshkumar *et al.* (2014) studied the effect of plant growth regulators on growth, flowering and yield of African marigold cv. Pusa Narangi Gainda. Among all the treatments, GA_3 at 300 ppm resulted in early flower bud initiation (48 days), opening of first flower (89.87 days) and maximum duration of flowering (50.47 days), flower stalk length (8.95 cm), number of flowers per plant (60.33), weight of flower (13.13 g), flower yield per plant (792.13 g) and flower yield per hectare (396.06 q) followed by GA_3 at 200 ppm.

Gopichand *et al*. (2014) studied the effect of bioregulators and stage of harvesting on seed maturity and quality in African marigold. Among all treatments GA_3 @ 200 ppm has recorded maximum flower weight (4.42g) and seed yield per flower (0.99g).

China aster

Bose (1965) observed an increase in plant height in China aster, carnation, corn flower and zinnia with GA_3 treatment.

Induction of early flowering and increased flower size in China aster was noticed with the application of GA_3 at 200 ppm by Reddy and Sulladamath (1972) similarly, maximum plant height, more number of branches, more number of flowers per plant were obtained by spraying GA_3 at 200 ppm compared to control in China aster (Reddy and Sulladamath, 1983).

Application of GA_3 at 200 ppm resulted in maximum plant height (58.93 cm), more number of branches per plant (13.77), more number of flowers per plant (84.80), compared to control (37.90 cm 6.80 and 16.30, respectively) in China aster (Lal and Mishra, 1986).

The maximum plant height, number of leaves, number of branches, more number of flowers and seed yield per plant were recorded in the plants sprayed with GA_3 at 200 ppm as compared to control in China aster (Syamal *et al,* 1990).

In china aster, Shetty (1995) reported that foliar spray of GA_3 at 200 ppm significantly increased the germination percentage (90.75 %), vigour index (660), plant height, number of branches per plant, less number of days for 50 per cent flowering, increased number of seed heads per plant, seed yield per plant, per hectare and thousand seed weight compared to control.

In china aster application of different growth regulators significantly affected the weight of seeds per plant. The seed weight per plant was highest in the plants treated with GA_3 at 200 ppm (7.21 g), which was followed by IAA at 100 ppm (6.14 g) and GA_3 at 100 ppm (6.21 g). GA_3 at 200 ppm also resulted in the highest seed weight (764.26 kg/ha) and the 1000 seed weight (2.358 g), which was statistically superior to the control. Although 100 ppm IAA, 100 ppm GA_3, 300 ppm $GA_3$and 50 ppm IAA increased the weight of 1000 seeds, but found statistically at par with control (Geetha *et al.,* 2000).

Doddagoudar *et al.* (2002) reported that spraying of GA_3 at 200 ppm resulted in maximum plant height at harvest (50.80 cm), more number of leaves per plant (13.60), number of capitula per plant (26.30), filled seed (79.40 %), seed yield per plant and per hectare (6.56 g and 1486.20 kg, respectively) and 1000 seed weight (1.90 g) in China aster cv. Kamini.

Jayabalakrishnan and Sekar (2002) studied the effect of nitrogen and gibberellic acid on growth, flowering and yield of China aster. Application of N at 200 kg/ha along with two sprays of gibberellic acid at 300 ppm at fortnight intervals commencing from 30 days after transplanting produced highest plant height at final harvest stage (74.00 cm), number of branches per plant (26.67), number of leaves per plant (97.33), flower diameter (6.45 cm), flower stem length (51.67 cm) and single plant yield (37.85 g).

Prabhatkumar *et al.* (2003) noticed maximum plant height (62.00 cm), number of branches per plant (20.27), more number of flowers per plant (67.33), flower weight (2.86 g) and flower yield (192.59 g/plant) When plants were treated with $GA_3$200 ppm as compared to control (46.77 cm, 16.57, 65.67, 2.81 g and 184.51 g, respectively) in China aster cv. Kamini.

Doddagoudar *et al.* (2004) reported that spraying with GA_3 at 200 ppm in China aster recorded significantly highest seedling dry weight (18.0 mg) which was found to be on par with Malic Hydrazide at 500 ppm (17.50 mg) and it was followed by Malic Hydrazide at 500 ppm (15.5 mg), while control recorded the lowest seedling dry weight (12.80 mg). Seedling vigour index was also significantly influenced by all chemicals compared to control. However, maximum germination percentage (93.00 %), shoot length (3.77 cm), root length (1.56 cm), seedling vigour index (496) were recorded with GA_3 200 ppm application followed by boron 0.1 per cent (463) and MH at 500 ppm (433) application.

Katkar *et al.* (2005) reported that foliar application of GA_3 at 200 ppm showed early bud emergence (56.26 days), 50 per cent flowering (80.46 days), more number of flowers per plant (49.98) and yield per plot (2623.00 g / m^2) in China aster cv. California Giant Mix.

Nandre *et al.* (2009) found that foliar application of GA_3 at 200 ppm recorded maximum plant height (50.43 cm), branches per plant (14.60), more number of leaves per plant (80.60), highest flower yield per plant, per plot and per hectare (110.00 g/plant, 4.96 kg/plot and 122.44 q/ha, respectively). Whereas, it was less days for flower initiation and 50 per cent flowering (54.33 and 64.33 days, respectively) in the treatment GA_3 at 100 ppm in China aster.

Pavan *et al.* (2015) studied effect of plant bio-regulators on growth, flowering and seed yield in china aster cv. Kamini. GA_3 @ 200 mg/l spray recorded significantly higher plant height (60.10 cm), number of primary branches per plant (24.60) and number of secondary branches per plant (61.45) at 90 DAT, number of flowersper plant (84.96), flower yield per plant (109.66 g), flower yield per hectare (16.58 t).

Chrysanthemum

Spraying of GA_3 at 200 ppm resulted in maximum plant height (80.40 cm), basal diameter of plants (0.76 cm), internodal length (5.90 cm), dry matter of leaves (22.2 %), leaf area (58.00 cm^2) size of the flower (8.80 cm) and peduncle length (22.00 cm) in chrysanthemum (Sen and Maharana, 1972).

Foliar spray of GA_3 at 400 ppm on chrysanthemum cultivars White and Yellow resulted in increased plant height (57.38 and 41.00 cm, respectively), early flowering (84.00 and 81.00 days, respectively), increased duration of flowering (95.50 and 140.00 days, respectively) and number of flowers per plant (44.30 and 42.50, respectively) (Shanmugam and Muthuswamy, 1974).

Bankar (1980 b) observed highest plant height (81.30 cm), diameter of the stem (1.56 cm), number of branches per plant (106.75), early flowering after transplanting (60.75 days), increased number of flowers per plant (99.00) and length of peduncle (5.97 cm) with gibberellic acid at 80 ppm in *C. indicum* cv. Yellow.

Nagarjuna *et al*. (1988) reported that plants sprayed with GA_3 (100 and 200 ppm) took less time to 50 percent flowering (17 to 21 days) and recorded maximum flower diameter (5.92 to 5.99 cm) with GA_3 200 ppm application in *C. indicum* L.

Antably *et al.* (1991) reported that exogenous application of GA_3 at 15 days after planting in chrysanthemum (*Dendranthema morifolium*, a short day plant and *C. frutescence,* a long day plant) resulted in increased root numbers and activity of growth promoting substances in the basal parts of cuttings, while exogenous application abscissic acid treatment reduced root numbers and increased the activity of growth inhibitors in the basal parts of cuttings.

Talukdar and Paswan (1995) reported that treating the rooted cuttings of chrysanthemum cv. Rajkumari at 35 days after planting with GA_3 (10, 20 and 40 ppm) and CCC (5000 ppm) resulted in increased plant height. The increase in plant height was positively correlated with GA_3 concentration.

Foliar application of GA_3 at 40 ppm on chrysanthemum Prof. Harris resulted in the largest flowers, followed by 5000 ppm CCC (7.90 and 7.80 cm, respectively) application compared to control flowers (Talukdar and Paswan, 1996).

Dutta *et al.* (1998) studied the response of chrysanthemum to treatments with NAA (50, 75 and 100 ppm), GA_3 (50, 100 and 150 ppm), MH (250, 500 and 1000 ppm) and CCC (2000, 3000 and 4600 ppm). Plant height, internodal length, number of lateral nodes and leaves per plant were markedly increased by all treatments as compared with control plants. GA_3 at 150 ppm recorded the maximum plant height, longest internodes and maximum number of laterals.

Talukdar and Paswan (1998) noticed increased plant height and flower yield at the maximum in four standard chrysanthemums treated with GA_3 (40 ppm). Similarly, GA_3 treatments (10, 20 and 40 ppm) increased the number of leaves in all the cultivars (Snow Ball, Kiku Biori and Lilac) except in Grape Bowl. Leaf area was increased by GA_3 (40 ppm) treatment in Snow Ball, KikuBiori and Lilac.

The effect of plant growth regulators (GA_3 and NAA at 10, 50 and 100 ppm and CCC at 500, 1000 and 1500 ppm) on growth and flowering of chrysanthemum was investigated. Maximum plant height was obtained with 100 ppm GA_3 as compared to control. NAA also showed increased plant height as compared to control. GA_3 application resulted in early flowering, while NAA and CCC delayed the flowering. The earliest flowering was with the plants of sprayed by 100 ppm GA_3 (Godha *et al.,* 2000). Further Padmapriya and Chezhiyan (2002) found that application of GA_3 at 100 ppm resulted less days for flowering from bud initiation (54.25 days), 50 per cent flower opening (123.38 days) and more length of the stalk (28.09 cm) whereas application of GA_3 at 150 ppm recorded enhanced duration of flowering (60.50 days) and diameter of the flower (5.91 cm) in chrysanthemum. Further Padmapriya and Chezhiyan (2003) studied the effect of growth regulators on different chrysanthemum cvs. Baggi, Indira, Red Gold and Shyamal. Among the different growth regulators, spraying of GA_3 at 150 ppm resulted in highest plant height (67.88 cm) in cv. Shyamal. Red Gold treated plants with 150 ppm GA_3 and 100 ppm salicylic acid gave the highest number of branches per plant and flower yield per plant (15.75 and 370.65, respectively).

Rakesh *et al.* (2003) reported that spraying of GA_3 at 200 ppm resulted in maximum plant height (48.00 cm and 70.54 cm), plant spread (32.05 cm and 37.57 cm respectively), more number of branches per plant (13.57 and 16.16) and yield per plant (117.76 g and 84.06 g respectively). Further Rakesh *et al.,* 2004 reported that the quality

and yield of flowers increased significantly over the control in plants sprayed with 50 to 200 ppm GA_3. Flower size and flower stalk length were highest in non-pinched plants and sprayed with 200 ppm GA_3. Whereas, the yield of flowers per plant was highest in plants pinched at 35 days after planting and sprayed with 200 ppm GA_3 in chrysanthemum Cv. Flirt and Gauri.

Induction of early flowering (88.60 days) with the application of GA_3 at 200 ppm as compared to control (97.1 0 days) in chrysanthemum was noticed by Kulkarni and Reddy (2004).

Sharmilabharati and Sekar (2005) reported that application of combination of neem cake coated urea (8.00g/plot) and GA_3 (100 ppm) resulted in maximum leaf area (13 .11 cm^2), number of laterals per plant (11.67), early flowering (100.00 days), more number of flowers per plant (102.00) and flower diameter (5.27 cm) in chrysanthemum.

Gautam *et al.* (2006) reported that spraying of GA_3 at 200 ppm resulted in more plant height at harvest (72.27 cm), stem diameter (9.35 mm), number of branches per plant (23.67), plant spread (25.05 cm), flower weight (2.85 g), diameter of flower (7.11 cm), number of flowers per plant (44.94), weight of flowers per plant (128.11 g), weight of flowers per bed (2.05 kg) and flower yield (14.23 t/ha) in chrysanthemum cv. Nilima.

Dalal *et al*. (2009 a) reported increased plant height (95.00 cm), less days to bud emergence and flowering (68.75 and 88.50 days, respectively), more number of flowers per plant (87.35), highest yield per plant and per square meter (0.233 g and 0.778 kg, respectively), flower diameter (8.45 cm), flower stalk length (18.57 cm) were recorded with the spraying of GA_3 @ 200 ppm in chrysanthemum under net house conditions.

Akalde *et al*. (2010) opined that GA_3 at 100 ppm was found to be beneficial for increasing the all characters under study and noticed maximum plant height (68.30 cm), minimum days for blooming (61.59 days) large flower size (7.39 cm), stalk length (13.87 cm), fresh weight (3.88 g) and shelf life of flowers (11.08 days) of flowers. It was also produced maximum number of flowers per plant (44.33) and flower yield (19.24 t/h) in chrysanthemum.

Sainath *et al*. (2014) studied effect of different growth regulators on seed yield and quality attributes in annual chrysanthemum (*C. coronarium* L.). Spraying of GA_3 @ 200 ppm significantly increased number of capitulum per plant, capitulum diameter, number of seeds per capitulum, dry weight of capitulum, 1000 seed weight and seed yield per plant and per ha as compared to control. The seed quality parameters such as germination percentage, seedling length and vigour index and seedling dry weight were higher with lower electrical conductivity with GA3 @ 200 ppm followed by GA_3 @ 100 ppm.

Daisy

Girish *et al*. (2012) reported maximum plant height (30.75 cm), number of leaves (44.75), chlorophyll contents of leaves, spike length (28.8 cm) and rachis length (26.53 cm) in plants sprayed with GA_3 at 150 ppm whereas, wider flower diameter was noticed in GA_3 at 200 ppm. Control plants recorded significantly minimum plant height, number of leaves, chlorophyll contents of leaves, spike length and rachis length.

Dahlia

Mittal (1967) observed the increased fresh weight and dry weight of the flowers (147.6 and 19.4 g, respectively) and also early flowering with spraying of GA_3 at 200 ppm in dahlia.

Bhattacharjee (1984) reported that spraying of GA_3 at 100 ppm resulted in more number of leaves on the main stem (19.60), number of branches (8.60), basal diameter of the stem (1.20 cm), early flower bud emergence (55.00 days), number of flowers per plant (17.00) and diameter of terminal flower (15.90 cm) in dahlia cv. Kelvin Rose.

Sindhu and Verma (1998) opined that gibberellic acid at 100 ppm concentration was significantly effective to increase the plant height and size of the flowering head in dahlia cv. Powder Puff.

Khan and Tewari (2003) reported that GA_3 at 90 ppm significantly increased the plant height (69.00 cm), number of branches per plant (6.60), more number of flowers per plant (15.80) compared to control (58.52 cm, 6.10 and 13.37, respectively) in dahlia.

Gaillardia

Bankar (1980 a) reported early germination of gaillardia (*Gaillardia pulchella*) seeds by one to two days, when treated with GA_3 @ 60 ppm. Germination per cent was also higher (64 - 86 %) in treated seeds as compared to control (58 - 62 %).

Ghadage *et al.* (2010) reported that treatment of GA_3 @ 200 ppm resulted in maximum height of plants, number of leaves, big size of flower and stalk length of flower in Gaillardia .This indicated that GA_3 is beneficial to obtain maximum yield and quality of flower.

Gerbera

Spraying of GA_3 at 100 ppm resulted in maximum plant spread (31.10 cm), more number of leaves per plant (15.19), more number of flowers per pot (18.63), diameter of flower head (7.53 cm) compared to control in gerbera (Sujatha *et al*. 2002).

Dalal *et al.* (2009 b) noticed maximum vegetative growth, flower yield and quality were observed with treatment of GA_3 at 150 ppm, but early flowering was noticed in 50 ppm GA_3 spray in gerbera plants under poly house conditions.

Anuradha *et al.* (2010) studied the effect of GA_3 on growth and yield of gerbera and reported that GA_3 at 100 ppm gives maximum plant height and number of leaves per plant and yield of gerbera.

Other flower crops

Ravidas *et al.*(1992) reported that GA_3 @ 100 ppm resulted in maximum plant height (53.87 cm) and more number of leaves per plant (6.33) GA_3 at 50 ppm gave maximum number of florets (16.0) per spike, weight of corm (35.61 g) and weight of cormels (13.48 g) in gladiolus compared to control (44.90 cm and 4.67, respectively)

In rose cv. Super Star Goyal and Gupta (1996) reported that spraying of GA_3 at 45 ppm showed increase in plant height (91.63 cm), shoot length (37.71 cm), shoot diameter (1.01 cm), number of flowers per plant (19.50), flower diameter (9.55 cm), flower weight and flower yield per plant (13.91 and 249.29 g, respectively)

Arun *et al.* (2000) recorded more plant height (80.45 cm), shoot length (63.13 cm), flower neck length (9.07 cm), total stem length (74.60 cm). Whereas, spraying of GA_3 at 200 ppm resulted in early flowering (40.66 days), maximum bud length (3.7 cm), bud circumference (5.93 cm), flower diameter (6.90 cm) and number of flowers (38.61 flowers/m^2) in rose cv. First Red when GA_3 was sprayed at 300 ppm.

Mishra *et al.* (2000) reported that dipping of football lily bulbs in GA_3 at l50 ppm had increased the plant height (43.70 cm), more number of leaves per plant (8.50), early flowering (95.40 days), increased inflorescence diameter (15.91 cm) and flowering life on plant (8.80 days).

Singh and Bijimol (2001) observed that the an increase in plant height (35.15 cm) and more number of leaves (32.83) per plant in tuberose with GA_3 200 ppm treatments compared to control (21.87 cm and 18.91, respectively).

Mourya and Nagda (2002) noticed the maximum plant height (104.50) in the plant treated with GA_3 100 ppm as compared to control (95.10) in gladiolus cv. Friendship.

Sharma *et al.* (2004) revealed that spraying of GA_3 100 ppm recorded maximum plant height (58.40 cm), spike length (92.20 cm), spike weight (82.60 g), and number of spikes per plant (1.24) in gladiolus.

Singh (2004) reported that treating the seeds of zinnia with GA_3 at 30 ppm recorded maximum length of shoot (6.44 cm), length of root (4.63 cm), fresh weight of five seedlings (281.36 mg) and dry weight of five seedlings (25.00 mg).

In tuberose cv. Double, Kumar *et al.* (2004) reported that GA_3 at two concentrations (100 and 150 ppm) increased the water uptake (45.83 and 44.28 g), vase life (8.76 and 8.54 days), fresh weight (54.73 and 56.56 %) and opened florets per spike (53.68 and 52.16, respectively.

Vijai and Singh (2005) reported maximum number of spikes per plant (1.93), and minimum days to taken for to corm sprouting (21.13 days) in spraying the corms with 150 ppm GA_3.

Padaganur *et al.,* 2005 revealed that spraying of GA_3 at 150 ppm recorded maximum plant height (31.52 cm), number of leaves (40.68), number of shoots (8.67), early spike emergence (137.67 days), spike length (86.01 cm), spike weight (28.09 g), number of florets per spike (52.97), floret length (5.69 cm) and floret diameter (0.817 cm) in tuberose cv. Single.

Chandrappa *et al.* (2006) recorded the maximum plant height (46.44 cm) with spraying of GA_3 750 ppm compared to control (45.22 cm) in anthurium cv. Royal Red.

Sharma *et al.* (2006) reported that soaking of gladiolus corms in GA_3 at 200 ppm resulted in early sprouting (6.54 days), maximum plant height (100.47 cm), number of leaves per plant (6.49), leaf length (85.00 cm), leaf area (159.22 cm^2), early flowering (82.77 days), maximum spike length (73,96 cm), number of florets per spike (18.01), floret length (13.01 cm), number of corms per plant (2.33), corm weight (47.95 g) and vase life (14.33 days) than control.

Kumar *et al.* (2007) noticed that treating of cut spike of tuberose in GA_3 at 125 ppm increases water uptake (46.93 ml/spike), vase life (8.72 days) and per cent of open florets per spike (56.09 %). Dipping the corms at 200 ppm of GA_3 recorded maximum corm weight (66.37 g), whereas spraying of GA_3 500 ppm resulted in maximum weight of cormels (6.14 g) per plant and maximum diameter (5.63 cm) of corms in gladiolus (Baskaran *et al.,* 2009).

Parmar *et al.* (2009) reported that GA_3 @ 200 ppm and NAA @ 100 ppm was effective in increasing growth, yield and flowers of Spider lily .Among these GA_3 @ 200 ppm resulted in early flowering (61.14 days) more number of flowers per spike (17.32) and maximum yield of flowers followed by NAA 100 and 200 ppm.

Kazaz and Karaguzel (2010) revealed that foliar application of GA_3 at 15 days interval at the concentration of 250 mg/l to the golden rod cv. Tara shortened the days to flower (90.00), increased the stem length (83.33 and 78.61 cm, respectively), stem diameter (7.40 and 7.32 mm, respectively), stem fresh weight (41.29 and 33.14 g, respectively), number of secondary inflorescences (31.43 and 29.70, respectively) and number of stems per (1.62 and 1.45, respectively).

Shinde *et al.* (2010) observed significantly maximum plant height (75.77 cm) number of branches (14.87), plant spread (35.91 cm and 35.30 cm in N-S and E-W respectively), number of suckers per plant (17.91), number of flowers per plant (49.82), yield of flowers per hectare (13.76)in plants sprayed with GA_3 @ 200 ppm and minimum days taken for flowering (111.79 days), maximum flower diameter (8.42) and vase life (15.92 days) was recorded in GA_3 150 ppm in chrysanthemum.

Amit *et al*. (2011) reported maximum plant height (43.78 cm and 66.96 cm in 45 and 90 DAT respectively), maximum number of flowers per plant (28.15) and fresh weight of flowers (12.45 g) in spraying of GA_3 350 ppm in African marigold cv. Pusanarangigainda.

Zahoor *et al.* (2011) evaluated the new generation growth regulators for increase in leaf number, leaf area and leaf dry matter in grape which is important factors for berry development and they observed that the combination of BR at lower concentration with CPPU and GA produced the significantly higher in leaf number, leaf area and leaf dry matter than control.

Rani *et al.* (2015) studied the assessment of growth, floral and yield attributes of gladiolus in response to gibberellic acid treatment. The results showed that maximum vegetative attributes of plant in respect of plant height, number of leaves per plant, leaf length and leaf width and floral attributes *viz.* spike length, rachis length, number of florets per spike, floret length and floret diameter were recorded to be maximum at100 ppm GA3 as compared to control. Days regarding to sprouting of corms and spike emergence were noticed to be minimum by GA3 pretreated corms at 150 ppm. A dose of 100 ppm GA3 among all the concentrations proved to enhancing yield attributes like corm and cormel production. Likewise, there was a significant increase in durability of spikes, chlorophylla, and carotenoid content at 100 ppm GA3.

2.1.2 Naphthalene acetic acid (NAA)

NAA (α - Naphthalene acetic acid) belongs to the auxin group of growth regulators and it is a synthetic auxin. Activity of the naphthalene acetic acid was first observed by Zimmerman *et al.* (1936). Actually auxins are synthesized in the stem and root apices and transported through the plant axis. They are characterized principally by

their capacity to stimulate stem elongation in excised stem and coleoptile section, but also influence a host of other development responses, including root initiation, vascular differentiation, tropic responses and development of auxiliary buds, flowers and fruits. Auxins are essential for enlargement and development of ovary into a fruit (Salibury and Ross, 1969).

2.1.2.1 Effect of NAA on growth, flowering, quality and yield parameters

Chrysanthemum

Saini and Arora (1974) noticed that NAA is only effective when applied before flower initiation. Other characters like flower size, length of the flower stalk and plant height of chrysanthemum were not influenced by NAA application.

Sharma *et al.* (1995) studied the effect of foliar application of malic Hydrazide (250, 500, 750 and 1,000 ppm) and NAA (25, 50, 75 and 100 ppm) on chrysanthemum cv. Move-In-Carvin. They reported that spraying with MH or NAA delayed bud break.

Waseem *et al.* (2009) reported that lowest concentration of NAA 0.5 mg/l showed the best response towards the regeneration of chrysanthemum plantlets, as it yielded the maximum percentage of shoot initiation (70.00 %), average shoot per explants (2.00), shoot length (2.60 cm), leaves per shoot (5.30) and nodes per shoot (3.10).

Gerbera

Warar *et al.* (2008) found that, MS medium supplemented with 0.5 mg per liter NAA recorded maximum percentage of rooting (100.00 %), number of roots per explant (5.50) and root length (2.3 cm) in gerbera var. Sciella.

Marigold

Singh and Rathore (1992) observed increase in plant height (161.07 cm), number of primary branches per plant (17.26) and more number of flowers per plant (29.00) in African marigold by the application of NAA at 25 ppm treatment compared to NAA at 50 ppm (148.40, 15.50 and 26.10 cm, respectively).

Other flower crops

Bhattacharjee (1984) obtained the maximum plant height (81.00 cm) and number of branches per plant (6.00) with spraying of NAA at 100 ppm compared to control (69.20 cm and 5.40, respectively) in dahlia.

Application of NAA at 100 ppm gave maximum plant height (67.60 cm), more number of leaves (30.00), number of flowers per spike (28.00) and number of flower spikes per plant (6.50) compared to control (45.00 cm, 18.00, 11.0 and 2.30, respectively) in day lily (Das *et al.*, 1992).

Maurya and Nagda (2002) noticed delayed flowering by application of NAA at 100 ppm (101.30 days) compared to NAA spray at 50 ppm (95.00 days). However, NAA at 50 ppm produced more spike weight (87.70 g), number of florets per spike (16.30) and number of spikes per hectare (2.22 lakhs) compared to control (77.90 g, 13.90 and 1.47 lakhs/ha, respectively) in gladiolus cv. Friendship.

Singh and Kumar (2003) reported that foliar application of NAA at 125 ppm on rose cv. Super Star gave maximum number of shoots per bush (13.77), number of leaves per bush (168.40), length of shoots (79.00 cm), flower diameter (12.32 cm), number of buds per shoot (5.67) and total number of flowers per bush (16.96).

Treating of *Clerodendrum splendens* cuttings with NAA at 1000 ppm recorded maximum percentage of rooting (90.96 %). Whereas, NAA at 2000 ppm recorded more number of primary roots per cutting (12.25), length of the longest primary root (28.70 cm) and length of rooting zone (4.62 cm) was reported by Vinaykumar *et al.* (2008).

Girish *et al*. (2012) observed 150 ppm concentration of IBA and NAA as optimum to increase the plant height, number of spikes, flower yield, vase life of flowers and dry weight, whereas 100 ppm IBA and 150 ppm NAA optimum to increase the plant spread and size of flower in daisy (*Aster amellus* L.).

Vasudevan *et al*. (2000) reported that combination of TIBA (240 ppm) and NAA (50 ppm) was found to improve all seed quality parameters that is germination percentage (93.50 %), shoot length (23.58 cm), root length (20.77 cm) and vigour index

(4126) compare. to control (88.0%, 20.75 cm, 18.83 cm and 3471, respectively) in sunflower genotypes.

Vasudevan *et al*. (2002) recorded maximum 1000 seed weight (65.30 g) and seed yield per hectare (40.80 q) with spraying of TIBA (100 ppm) + NAA (50 ppm) in sunflower cv. KBSH-I compared to control (60.60 g and 35.10 q/ha, respectively).

2.1.4 2, 3, 5-triiodobenzoic acid (TIBA)

2.1.4.1 Effect of TIBA on growth, flowering, yield and quality of crossandra

Crossandra

Sayad and Muthuswamy (1974) reported that foliar spray of phosfon-D @ 250 ppm resulted in early flowering (123 days) and longer duration of flowering (210 days), maximum number of flowers per plant (376.5) and maximum flower yield per plant (27.52 g) whereas, all the concentrations of TIBA (100, 200, 400 ppm) resulted in reduced plant height, more number of laterals .The TIBA at 100 ppm gave more number of flowers per plant (209.5) and maximum yield per plant (13.19 g) compared to control in *Crossandra undulaefolia*.

Marigold

Among the growth retardants studied CCC, TIBA and MH suppressed plant height and enhanced the plant spread and number of laterals over control. TIBA at 1000 ppm recorded maximum flower diameter in marigold. (Naidu *et al.* 2014).

Other flower crops

Vasudevan *et al*. (2000) reported that combination of TIBA (240 ppm) and NAA (50 ppm) was found to improve all seed quality parameters that is germination percentage (93.50 %), shoot length (23.58 cm), root length (20.77 cm) and vigour index (4126) compare. to control (88.0%, 20.75 cm, 18.83 cm and 3471, respectively) in sunflower genotypes.

Vasudevan *et al*. (2002) recorded maximum 1000 seed weight (65.30 g) and seed yield per hectare (40.80 q) with spraying of TIBA (100 ppm) in combination with

NAA (50 ppm) in sunflower cv. KBSH-I compared to control (60.60 g and 35.10 q/ha, respectively).

Ahmed *et al.* (2013) reported 2,3,5 triiodobenzoic acid can be used for producing dwarf tulips suitable for bedding and pot plant production. CCC and TIBA caused delayed sprouting with most pronounced in CCC 750 ppm (90.00 days) and TIBA 200 ppm (89.23 days) as compared to control. TIBA at a higher dose of 200 ppm significantly delayed flowering by exhibiting 29.50 days to floral bud appearance, 9.23 days to colour break and 6.67 days to flower opening in tulip.

Abdul and Thompson (1969) reported TIBA decreased the number of laterals reduced the early yield and delayed maturity treatment with at 50 ppm delayed harvest but did not significantly reduce yield. TIBA or IAA modified sex expression toward femaleness in watermelon.

Mourya *et al*. (2003) reported the effect of plant growth regulators on growth, flowering and yield characteristics. TIBA at100 ppm recorded the highest number of branches per plant with Sharad Shrungar. Flowering was hastened with 150 ppm gibberellic acid but was delayed with TIBA. Further Mourya *et al*. (2003) conducted an experiment to find out the effects of gibberellic acid (GA_3) at 100 and 150 ppm, and TIBA at 100 and 200 ppm on the growth and flowering of chrysanthemum cvs. Sonali Tara, Birbal Sahani, Sharad Shrungar and Julia. Sharad Shringar sprayed with 100 ppm TIBA recorded the highest number of branches per plant (21.1) and delayed flowering.

Geng *et al.* (2005) reported the effects of TIBA on growth and flowering of non-pre-cooled tulip bulbs. Application of GA_3 in combination with TIBA induced higher flowering rates and earlier flowering than the application of only GA_3 when the bulbs were planted in November and later, and TIBA induced the elongation of the internodes, particularly of the lower internodes and 100 percent flowering and reduced the days to flowers.

Ali and Afrasiab (2014) reported that MS medium supplemented with 2.0 µ MTIBA, maximum response to callus induction was shown by root (96%) followed by internode (93%) and leaf (90%) explants, respectively under dark condition in safflower.

Sheetalben *et al*. (2015) studied the effect of growth retardants on the vegetative growth, flowering and yield of heliconia **(***Heliconia psittacorum***)** var. Red Torch under 50 per cent shade net condition. The experimental results revealed that among all growth retardants, paclobutrazol @ 300 ppm drastically suppressed plant height (24.86 cm, 25.95 cm, 27.20 cm and 49.60 cm) at 3, 6, 9 and 12 month after planting, respectively and it was at par with 150 ppm paclobutrazol and followed by TIBA.

2.1.5 Ethylene

Effect of ethrel on growth, flowering, yield and quality parameters

Crossandra

The importance of ethylene as important hormonal regulator of physiological processes was realized only after the advent of gas chromatography (GC) and its use in ethylene research, soon this was followed by an avalanche of experimental research work on ethylene and finally ethylene emerged as an accepted natural plant growth hormone. Physiological effects of ethylene are fruit ripening, plumular hook formation, triple response, formation of adventitious roots and root hairs, inhibition of root growth, leaf epinasty, flowering, sex expression, senescence, abscission of leaves and breaking of dormancy of seeds and buds.

Crossandra

Subramanyam *et al.* (1988) studied use of growth regulators in crossandra which revealed that ethrel at 100 ppm gave the maximum number of flowers per plant (723.4) and maximum yield per plot (254.63 g) followed by TIBA 50 ppm which gave 690.23g per plot flowers with a yield of 242.48g. Ethrel 100 ppm and NAA 50 ppm recorded maximum storage life of 84 hr.

Other crops

Jamil *et al*. (2015) studied on effect of plant growth regulators on flower and bulb production of Hippeastrum (*Hippeastrum hybridum* Hort.). Ethrel at a concentration of 100 ppm increased the number of flowers per scape (4) and showed earliness in days to flower scape emergence (72.33 days) and first flower open (88.67 days).

Ananth and Kumar (2012) observed that the application of ethrel at 2000 ppm has got maximum number of branches per plant (28.31), fresh weight (2379.13 g) and dry weight (473.65 g) as compared to control in nerium.

Mithilesh *et al.* (2014) reported that application of ethrel at 400 ppm gave maximum number of flower per plant (50.80), diameter of the flower (7.58 cm), duration of flowering (45.93), weight of flower (11 g) and yield per hector (279.40 q) as compare to control in african marigold.

3. MATERIAL AND METHODS

The investigation was carried out to study the “effect of growth regulators on growth, flowering and yield of crossandra (*Crossandra undulaefolia* Salisb) genotype ACC-1. (Ghataprabha Left Bank Channel) conditions in northern dry zone of Karnataka. The study was conducted at the Department of Floriculture and Landscape Architecture of Kittur Rani Channamma College of Horticulture, Arabhavi during June 2015 to February 2016. The general view of the experimental plot is presented in Plate-1. The details of the material used and the methods adopted during the course of investigation are presented in this chapter.

3.1 Geographical location of the experimental site

Arabhavi is situated in Northern dry tract of Karnataka state at 16° 15´ North latitude and 94° 45´ East latitude. It is located at an altitude of 612 m above mean sea level. Arabhavi lies in Zone-3 of Region-2 of agro climatic zones of Karnataka. The region is commonly known as Ghataprabha Left Bank Canal Area as the area is under coverage of the canal water from Hidkal Dam.

3.2 Climatic conditions

The total rainfall of this area is about 355.00 mm per year, which is distributed over a period of seven to eight months from May to November with prominent peak during June to October. The highest rainfall during the period of experimentation was in May followed by June.

The mean maximum temperature during the period of experimentation ranged from 11.62°C to 26.90°C. The mean minimum temperature during the same period ranged from 28.48°C to 37.50°C. The mean relative humidity ranged from 61.13 per cent to 70.30 percent. The meteorological data recorded during the experimental period is presented in Appendix I.

3.3 Materials for investigation

3.3.1 Genotype and their source

A local genotype having yellow colour were collected from different locations of Khanapur farmers field from different locations. It is mentioned as Arabhavi crossandra collection-1 (ACC-1).

3.4 Experiment-1: Effect of growth regulators on growth, flowering and yield Crossandra genotype ACC-1

3.4.1 Experimental details

Experimental design and layout

The experiment was laid out by adopting randomized completely block design (RCBD). The layout of an experiment is given in Fig 1.

Location : Floriculture field, KRCCH, Arabhavi

Design : RCBD

Genotype : One

Replications : Three

Spacing : 60 x 30 cm

Net plot area : 2.7 m^2

3.5 Cultural operations

3.5.1 Raising of cuttings

The cuttings of various collections of length 10-15 cm were raised in pots containing mixture of sand, vermicompost and FYM in 2:1:1 proportion and drenched with methyl bromide @ 2 mg /l and watered regularly during first week of June 2015.

For better root development IBA- 3000 ppm for 30 minutes was used. The vegetative cuttings were ready for transplanting after 70 days.

3.5.2 Preparation of experimental plot

The land was brought to a fine tilth by repeated ploughing and harrowing. The plot of requisite dimension was prepared as per the plan. A gap of 0.5 m between three replications was provided for laying out the irrigation channels and working space.

Treatments:

T1: GA_3 @ 100ppm

T2: GA_3 @ 200ppm

T3: NAA @ 100ppm

T4: NAA @ 150ppm

T5: TIBA @ 100ppm

T6: TIBA @ 150ppm

T7: Ethrel @ 50ppm

T8: Ethrel @ 100ppm

T9: Control

All these growth regulators were sprayed at the interval of 15, 30, 45 and 60 days after transplanting.

3.5.3 Transplanting

Cuttings of crossandra were ready for transplanting after 70 days. The ridges and furrows were opened at 60 cm and were planted on one side of the ridge at 30 cm distance. The transplanting was done during first week of August 2015 in kharif season. Irrigation was given after the planting.

R-III	R-II	R-I
T_4	T_9	T_1
T_5	T_8	T_2
T_6	T_7	T_3
T_1	T_5	T_4
T_2	T_6	T_5
T_3	T_4	T_6
T_9	T_3	T_7
T_7	T_2	T_8
T_8	T_1	T_9

Fig. 1. Layout of the experiment

3.5.3.1 Preparation of the chemical solution

The quantity of growth regulators required for investigation was dissolved in 1000 ml of distilled water.The growth regulators α-Naphthalene acetic acid (NAA) and TIBA was dissolved in two to three pellets of sodium hydroxide solution and final volume was made up to 1000 ml of distilled water. Whereas, Gibberellic acid (GA_3) and ethrel was directly dissolved in distilled water.

Table 1: Preparation of different plant growth regulators and their concentrations

Name of growth promoters	Quantity of growth regulator used in 1000 ml	Final concentration (ppm)
Gibberellic acid (GA_3)	100 mg	100 ppm
	200 mg	200 ppm
α- Naphthalene acetic acid (NAA)	100 mg	100 ppm
	150 mg	150 ppm
TIBA	100 mg 150 mg	100 ppm 150 ppm
Ethrel	0.1 ml 0.2 ml	50 ppm 100 ppm
Control (Water spray)	-----	-----

* Stock solution was prepared earlier of the concentration of 1000 ppm

3.5.4 Fertilizer application

Nitrogen, phosphorous and potassium (100:60:60 kg NPK /ha, FYM- 25 t /ha) were applied in the form of urea, single superphosphate and muriate of potash, respectively. At the time of transplanting, half of the dose N and full dose of P and K were applied in between the rows and the crop was top dressed with remaining half dose of N after 30 days after planting.

3.5.5 Weeding and Irrigation

The plots were kept free from weeds by periodic hand weeding. Irrigation was given at an interval of 6-7 days throughout the period of experimentation, depending on the soil moisture status and climatic conditions.

3.5.6 Plant protection

Plant protection measures were under took to protect the plants as and when pests and diseases noticed.

3.5.7 Harvesting

The flowers were harvested at two days interval when flowers were fully opened.

3.6 Collection of experimental data

3.6.1 Sampling procedure

From each experimental plot, five plants were randomly selected and tagged for recording observations on growth, yield and other pertinent parameters.

3.6.2 Observations on growth parameters

Observations on growth parameters like plant Height, number of branches, plant spread and stem girth were taken at 30, 60, 90, 120, 150 and 180 days after transplanting (DAT).

3.6.2.1 Plant height (cm)

The plant height was recorded in centimeters from the base to the tip of the tagged plants and average was worked out at 30, 60, 90, 120, 150 and 180 DAT.

3.6.2.2 Number of branches per plant

The number of branches was recorded from the tagged plants and average was worked out at 30, 60, 90, 120, 150, 180 DAT.

3.6.2.3 Leaf area (cm^2)

The leaf was measured by using leaf area meter by Biovis pvt. Ltd. The readings were taken from the tagged plants and leaf area was expressed in square centimeters (cm^2).

3.6.2.4 Plant spread (cm)

It was measured by recording the plant spread from North- south to East- West directions in the tagged plants at 30, 60, 90, 120, 150, and 180 (DAT). Average was worked out and expressed in centimeters.

3.6.2.5 Chlorophyll estimation (mg.g^{-1}fresh weight)

Chlorophyll content of leaf was analyzed by collecting the healthy, fully opened matured leaves from the centre portion of the plants at peak growth stage Chlorophyll 'a', 'b' and total chlorophyll content of leaf tissue were determined by using dimethyl sulphoxide (DMSO) as suggested by Shoaf and Lium (1976).The harvested leaves were brought in polyethylene bags from field and were cut into small pieces. Known weight of sample (100 mg) was incubated in 7.0 ml DMSO at 65^{0}C for 60 minutes. After the incubation, supernatant was collected by decanting. Then the volume of supernatant was made up to 10 ml using DMSO.The absorbance of extract was measured at 645 ηm and 663 ηm using DMSO as a blank in spectrophotometer. The chlorophyll 'a', chlorophyll 'b' and total chlorophyll content were calculated by using the following formula.

$$\text{mg chlorophyll 'a'/ g tissue} = [12.7\ (A_{663}) - (2.69\ X\ A_{645})]\ \frac{V}{1000} \times W$$

$$\text{mg chlorophyll 'b'/ g tissue} = [22.9\ (A_{645}) - (4.68\ A_{663})]\ \frac{V}{1000} \times W$$

$$\text{mg total chlorophyll / g tissue} = [20.2\ (A_{645}) + (8.02\ A_{663})]\ \frac{V}{1000} \times W \times a$$

A = Absorbance at specific wavelengths 645 ηm and 663 ηm

V = Volume of the extract (10 ml)

W = Fresh weight of the sample (100 mg)

a = Path of light in cuvette (1cm)

3.6.2.6 Carotinoid estimation (mg/g)

Carotinoid was estimated by using the DMSO method and absorption at 440 nm and carotinoid content were calculated by using the formula.

Carotinoid (mg/g) = ((1000(A_{454})-(2.86XChl. a) - (129.9XChl. b))/221

3.6.3 Observations on flowering attributes

3.6.3.1 Days taken to flower spike initiation

The number of days taken for commencement of flower bud initiation was recorded by counting the days from the date of transplanting to first flower bud initiation and expressed in days.

3.6.3.2 Days taken to first harvest

The number of days taken for first harvest of flowers was recorded by counting the days from the date of transplanting to first harvest of flowers and expressed in days.

3.6.3.3 Duration of flowering

The number of days taken from the date of first harvest of flowers till last harvest was recorded by counting the days from the date of first harvest of flowers and expressed in days.

3.6.4 Observations on yield and other parameters

3.6.4.1 Number of flowers per inflorescence

The total number of flowers produced on labeled five inflorescence per tagged plant was counted in the same five plants during flowering period.

3.6.4.2 Number of spikes per plant

The total number of spikes produced on tagged plants was counted during flowering 60, 90,120,150 and 180 days after transplanting.

3.6.4.3 100 flowers weight (g)

The weight of 100 flowers in each variety was taken from each replication and expressed in grams.

3.6.4.4 Flower yield per plant (g)

The total flower yield per plant was taken from the tagged plants at every harvest was summered and average was worked out and expressed in grams.

3.6.4.5 Flower yield per plot (g)

The total yields of flowers produced in the tagged plants as well as in all the plants in a treatment (plot) were recorded over the period of flowering and average was worked out and used for calculation of yield per plot and expressed in grams.

3.6.4.6 Flower yield per hectare (t)

The total yield per hectare was estimated based on the flower yield per plant, and per plot. It is expressed in tonnes.

3.6.4.7 Incidence of major pests and diseases

The regular incidence of pest and disease were observed and recorded. Control measures were taken up during the period of experimentation.

3.6.5 Observations on quality parameters

3.6.5.1 Flower diameter (mm)

Diameter of the flower was recorded from randomly selected flowers harvested at peak flowering stage in each treatment and average was worked out and expressed in mm.

3.6.5.2 Corolla length (mm)

The corolla length of the flower was recorded from randomly selected flowers harvested at peak flowering stage in each treatment using measuring scale and average was worked out and expressed in mm.

3.6.5.3 Shelf life (days)

Fresh flowers kept open on the paper plates at room temperature for the study. This was rewarded by counting the days until the flowers lost their visual marketable value.

3.6.5.4 Physiological loss in weight (%)

Physiological loss in weight (PLW) at six hours interval for two days. It is calculated by using following formula,

Physiological loss on n^{th} hour (%) = (Initial fresh weight - Fresh weight on n^{th} hour) x100

3.6.6 Economics

The price of the inputs and produce that prevails at the time of their use will be considered for working out the economics. Net returns per hectare will be calculated by deducting the cost of cultivation from gross income per hectare and benefit cost ratio (BC) will be worked out.

3.6.6.1 Cost of cultivation (Rs./ha)

The prices of all inputs prevailing at the time of their use and the labour cost were used to work out the cost of cultivation and expressed in rupees per hectare.

3.6.6.2 Gross return (Rs./ha)

The gross income was worked out based on the prevailing market of the flower and xanthophyll produce and expressed in rupees per hectare.

3.6.6.3 Net return (Rs./ha)

The net income per hectare was calculated on the basis of gross income and cost of cultivation per hectare and expressed in Rupees per hectare.

Net returns (Rs./ha) = Gross returns (Rs./ha) – Cost of cultivation (Rs./ha)

3.6.6.4 Benefit: cost ratio

$$\text{Benefit: Cost Ratio}\ (\%) = \frac{\text{Net return}\ \left(\frac{\text{Rs}}{\text{ha}}\right)}{\text{Cost of cultivation}}$$

3.7 Statistical analysis

The data on various biometrical parameters recorded during the period of investigation was tabulated and subjected to statistical analysis using factorial randomized complete block design (RCBD). The test of significance ('f' test) and critical difference (CD) were read at 0.05 probabilities (Sunderaraju *et al.*, 1972).

Plate 1: General view of experimental plot

Plate 2: Comparison of height between GA_3 (T_2) 200 ppm and control (T_9) treated plants

4. EXPERIMENTAL RESULTS

The results of an experiment entitled "Effect of growth regulators on growth, flowering and yield of crossandra (*Crossandra undulaefolia* Salisb) genotype ACC-1" undertaken at Kittur Rani Channamma College of Horticulture Arabhavi, are presented in this chapter. The results of experiments have been presented separately under the following headings.

4.1 Effect of growth regulators on growth, flowering and yield of crossandra (*Crossandra undulaefolia* Salisb) genotype ACC-1

4.1.1 Growth parameters

4.1.2 Flowering parameters

4.1.3 Yield and its attributing parameters

4.1.4 Quality parameters

4.1.5 B: C Ratio

4.1.1 Growth parameters

Growth parameters in different genotypes of crossandra *viz.*, plant height, number of branches, leaf area, plant spread and stem girth were analyzed and presented here under.

4.1.1.1 Plant height (cm) (30, 60, 90, 120, 150 and 180 DAT)

The data pertaining to plant height at different stages of growth in different growth regulators is depicted in Table 2. Results of the analysis indicated that there was significant difference in growth regulators sprayed *viz.*, T_1- GA_3 @ 100 ppm, T_2- GA_3 @ 200 ppm, T_3- NAA @ 100 ppm. T_4- NAA @ 150 ppm, T_5- TIBA @ 100 ppm, T_6- TIBA @ 150 ppm, T_7- Ethrel @ 50 ppm, T_8- Ethrel @ 100 ppm and T_9- control on 60, 90, 120, 150 and 180 DAT.

Table 2. Influence of different plant growth regulators on plant height (cm) at different stages of crop growth

Treatment details	Plant height (cm) at different DAT					
	30	**60**	**90**	**120**	**150**	**180**
T_1- GA_3 @ 100 ppm	30.00	40.23	51.24	57.77	62.90	64.60
T_2- GA_3 @200 ppm	30.43	41.53	56.00	62.80	69.50	71.10
T_3-NAA @100 ppm	28.32	37.53	44.36	49.47	53.77	55.04
T_4-NAA @150 ppm	28.11	36.07	39.07	43.17	50.03	51.44
T_5-TIBA @100 ppm	29.37	38.20	42.93	46.13	49.40	50.60
T_6-TIBA @150 ppm	28.29	39.80	41.23	45.73	50.63	52.43
T_7- Ethrel @50 ppm	28.20	34.69	40.33	45.93	50.20	52.63
T_8-Ethrel @100 ppm	28.54	35.37	40.67	46.67	50.27	51.57
T_9-Control.	29.15	33.93	38.03	41.43	46.83	48.61
S. Em (±)	0.87	1.54	1.43	1.06	1.13	1.09
CD at 5 %	NS	4.62	4.29	3.20	3.41	3.28

DAT: Days after transplanting**;** **NS:** Non significant

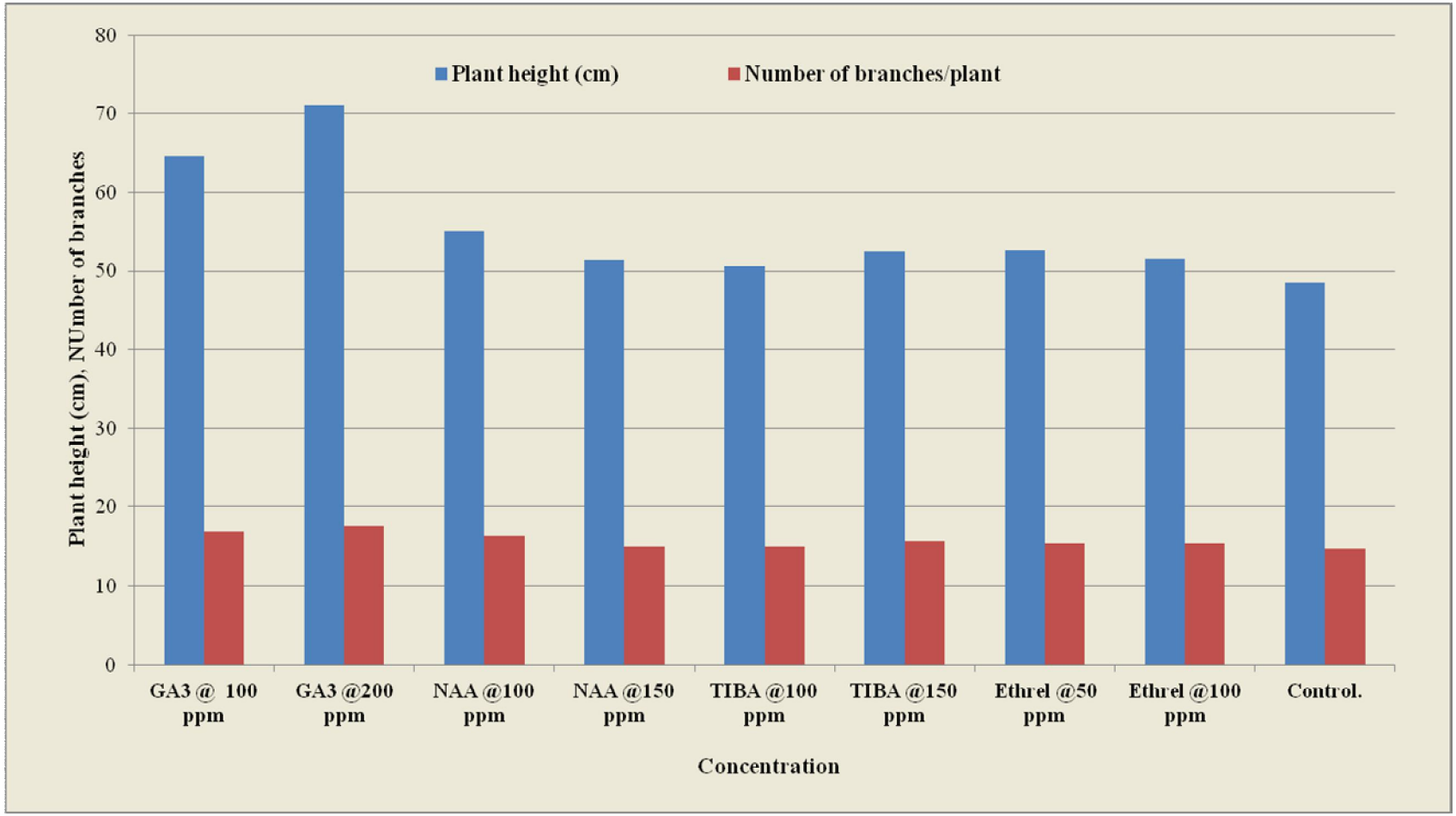

Fig. 2: Influence of different plant growth regulators on plant height and number of branches at 180 days after transplanting

At 30 DAT, the plant height was found to be non-significant which was varies from 28.11 to 30.43 cm.

At 60 DAT, among the different treatments plant height varied from 33.93 cm to 41.53cm. The treatment GA_3 at 200 ppm (T_2) showed highest plant height (41.53 cm) which was on far with GA_3 at 100 ppm (T_1), NAA @100 ppm (T_3), TIBA @100 ppm (T_5) and TIBA @150 ppm (T_6), the lowest plant height (33.93 cm) was found in control.

At 90 DAT stage, the plant height was observed in the range of 38.03 cm to 56.00 cm. Among the treatment, the treatment GA_3 at 200 ppm (T_2) was recorded tallest with a plant height of 56.00 cm. The plant height was minimum (38.03 cm) in control (T_9).

At 120 days after transplanting the plant height was maximum (62.80 cm) in treatment GA_3 at 200 ppm (T_2).The treatment nine (control) showed minimum plant height (41.43 cm).

At 150 DAT stage the plant height was observed in the range of 46.83 cm to 69.50 cm. Among the treatment, GA_3 at 200 ppm (T_2) was recorded highest with a plant height of 69.50 cm. The minimum plant height was recorded in control (46.83 cm).

At 180 days after transplanting the plant height was highest (71.10 cm) in treatment GA_3 at 200 ppm and it was minimum in the treatment T_9 (48.61cm).

4.1.1.2 Stem girth (mm)

Data pertaining to stem girth recorded for different growth regulator treatment is presented in Table 3.

Stem girth at 30 days after transplanting found to be significant among the different growth regulator treatment. The treatment GA_3 at 200 ppm (5.17 mm) found to be maximum in stem girth and it was found to be minimum in treatment control (4.16 mm).

Stem girth at 60 days after transplanting found to be significant among the treatment. The treatment GA_3 at 200 ppm (6.22 mm) recorded maximum stem girth

Table 3. Influence of different plant growth regulators on stem girth at different stages of crop growth

Treatment details	Stem girth (mm) at different DAT					
	30	**60**	**90**	**120**	**150**	**180**
T_1- GA_3 @100 ppm	4.71	5.75	7.95	11.77	13.48	14.15
T_2- GA_3 @200 ppm	5.17	6.22	8.46	12.22	14.05	14.71
T_3-NAA @100 ppm	4.45	5.63	7.65	11.11	12.53	13.23
T_4-NAA @150 ppm	4.71	5.45	7.58	11.25	12.55	13.26
T_5-TIBA @100 ppm	4.55	5.38	7.45	11.31	12.52	13.25
T_6-TIBA @150 ppm	4.53	5.53	7.66	11.21	12.23	12.97
T_7- Ethrel @50 ppm	4.61	5.35	7.64	10.99	12.66	13.39
T_8-Ethrel @100 ppm	4.50	5.44	7.35	11.14	12.55	13.22
T_9-Control.	4.16	4.79	7.31	10.83.	11.96	12.60
S. Em (±)	0.09	0.16	0.13	0.10	0.15	0.15
CD at 5 %	0.29	0.48	0.40	0.30	0.46	0.47

DAT: Days after transplanting**;** **NS:** Non significant

which was on par with treatment GA_3 at 100 ppm (5.75 mm) and it was found to be minimum in treatment control (4.79 mm).

The treatments differed significantly among themselves for the character of stem girth at 90 days. The treatment GA_3 at 200 ppm (T_2) recorded highest stem girth (8.46 mm), whereas control (7.31 mm) recorded minimum stem girth.

Stem girth at 120 days after transplanting found to be significant among the treatment. The treatment GA_3 at 200 ppm (T_2) found to be maximum (12.22 mm) in stem girth. The treatment control recorded minimum stem girth (10.83 mm).

At 150 days after transplanting maximum stem girth was recorded in GA_3 at 200 ppm (14.05 mm) and it was found to be minimum in control (11.96 mm).

The treatment differed significantly among themselves for the character of stem girth at 180 days after transplanting. Among the different treatments, GA_3 at 200 ppm (T_2) was given maximum stem girth (14.71 mm), whereas control (13.22 mm) recorded minimum stem girth.

4.1.1.3 Number of branches per plant

Data pertaining to number of branches produced per plant for different treatment is presented in Table 4.

Number of branches at 30 days after transplanting found to be significantly differing from all the treatments. Maximum number of branches (3.81) was recorded in the treatment GA_3 at 200 ppm which was on par with GA_3 at 100 ppm (3.53). The lowest number of branches (2.59) was recorded in treatment T_9 (control).

Number of branches per plant at 60 days after transplanting varied significantly among the growth regulator treatments. It was found to be maximum (6.47) in treatment GA_3 at 200 ppm (T_2) ant the lowest (4.40) was observed in control.

The genotype varied significantly for the trait number of branches at 90 days after transplanting. The highest number of branches was recorded in GA_3 at 200 ppm (11.20) and control (8.03) recorded lowest number of branches.

Table 4. Influence of different plant growth regulators on number of branches per plant at different stages of crop growth

Treatment details	Number of branches/plant at different DAT					
	30	**60**	**90**	**120**	**150**	**180**
T_1- GA_3 @ 100 ppm	3.53	5.93	9.83	14.20	16.17	16.83
T_2- GA_3 @200 ppm	3.81	6.47	11.20	14.40	16.97	17.63
T_3-NAA @100 ppm	3.43	5.60	9.40	12.57	15.57	16.37
T_4-NAA @150 ppm	3.21	5.50	8.37	12.48	14.33	15.05
T_5-TIBA @100 ppm	3.17	5.10	9.03	12.93	14.33	15.04
T_6-TIBA @150 ppm	3.12	5.13	9.20	13.03	15.07	15.70
T_7- Ethrel @50 ppm	2.85	5.10	8.73	12.13	14.71	15.46
T_8-Ethrel @100 ppm	2.85	4.97	8.30	12.60	14.73	15.48
T_9-Control.	2.59	4.40	8.03	12.00	14.13	14.78
S. Em (±)	0.10	0.12	0.20	0.48	0.19	0.19
CD at 5 %	0.31	0.37	0.61	1.46	0.59	0.57

DAT: Days after transplanting**;** **NS:** Non significant

Number of branches per plant at 120 days after transplanting varied significantly among the treatment. The treatment GA_3 at 200 ppm recorded highest number (14.40) of branches per plant, which was on par with GA_3 at 100 ppm (14.20) and TIBA at 150 ppm (13.03) whereas, control (T_9) recorded lowest number of branches per plant (12.00).

At 150 days after transplanting the number of branches per plant was highest (16.97) in T_2 (GA_3 at 200 ppm). The treatment control showed minimum number of branches per plant (14.13).

At 180 days after transplanting the number of branches per plant was highest (17.63) in GA_3 at 200 ppm and control recorded minimum number of branches per plant (14.78).

4.1.1.4 Leaf area

The data with respect to leaf area of different treatment for growth regulators are furnished in Table 5. Significant difference was observed among the treatment. The leaf area was maximum (3337.83 cm^2) in treatment GA_3 at 200 ppm and the minimum leaf area was recorded in treatment control (1590.84cm^2).

4.1.1.5 Plant spread East- West (cm)

Data pertaining to plant spread of different treatment of growth regulators is presented in Table 6.

At 30 DAT the plant spread East-West was found to be non-significant which was varies from 24.27 to 25.88 cm.

The treatment differed significantly for plant spread at 60 days after transplanting and it was observed in the range 26.0 cm to 30.63 cm. The treatment GA_3 at 200 ppm (T_2) continued to grow with a widest canopy of 30.63 cm spread, which was on far with GA_3 at 100 ppm (28.77). The least plant spread (26 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 90 days after transplanting. Plant spread was recorded in the range of 28.50 cm to 35.75

Table 5. Influence of different plant growth regulators on leaf area) and dry matter

Treatment details	Leaf area (cm^2)	Dry matter (g)
T_1- GA_3 @ 100 ppm	2760.40	73.40
T_2- GA_3 @200 ppm	3337.83	88.85
T_3-NAA @100 ppm	1762.34	38.59
T_4-NAA @150 ppm	1853.49	44.14
T_5-TIBA @100 ppm	1810.68	42.66
T_6-TIBA @150 ppm	1796.59	53.92
T_7- Ethrel @50 ppm	1645.93	50.00
T_8-Ethrel @100 ppm	1688.72	50.07
T_9-Control.	1590.84	42.50
S. Em (±)	139.21	3.44
CD at 5 %	417.63	10.32

Table 6. Influence of different plant growth regulators on plant Spread East-West (cm) at different stages of crop growth

Treatment details	Plant Spread East-West (cm) at different DAT					
	30	**60**	**90**	**120**	**150**	**180**
T_1- GA_3@ 100 ppm	25.60	28.77	32.82	47.15	49.95	51.28
T_2- GA_3 @200 ppm	25.88	30.63	35.75	49.31	52.27	53.61
T_3-NAA @100 ppm	24.50	26.84	31.35	46.67	48.02	49.35
T_4-NAA @150 ppm	24.83	27.22	29.74	44.27	47.59	48.93
T_5-TIBA @100 ppm	24.27	26.30	31.35	45.33	47.90	49.25
T_6-TIBA @150 ppm	24.37	26.60	29.33	45.68	47.39	48.73
T_7- Ethrel @50 ppm	24.37	26.70	30.80	45.06	47.14	48.48
T_8-Ethrel @100 ppm	24.83	26.47	30.79	45.46	47.93	49.27
T_9-Control.	24.27	26.00	28.50	42.17	44.91	46.65
S. Em (±)	0.67	0.78	0.61	0.72	0.93	0.96
CD at 5 %	NS	2.35	1.84	2.16	2.80	2.88

DAT: Days after transplanting**;** **NS:** Non significant

cm. The treatment GA_3 at 200 ppm (35.75 cm) had the maximum plant spread. The least plant spread (28.50 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 120 days after transplanting. Plant spread was recorded in the range of 42.17 cm to 49.31 cm. The treatment GA_3 at 200 ppm (49.31 cm) recorded maximum plant spread which was on par with treatment GA_3 at 100 ppm (47.15 cm). The least plant spread (42.17 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 150 days after transplanting. Plant spread was recorded in the range of 44.91 cm to 52.27 cm. The treatment GA_3 at 200 ppm (52.27 cm) observed maximum plant spread which was on par with treatment GA_3 at 100 ppm (49.95 cm). The least plant spread (44.91 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 180 days after transplanting. Plant spread was recorded in the range of 46.65 cm to 53.61 cm. The treatment GA_3 at 200 ppm (53.61 cm) recorded maximum plant spread which was on par with treatment GA_3 at 100 ppm (51.28 cm). The least plant spread (46.65 cm) was observed in control (T_9).

4.1.1.6 Plant spread North- South (cm)

Data pertaining to plant spread at different stages of crop growth for different treatment of growth regulators are presented in Table 7.

At 30 DAT the plant spread North-South was found to be non-significant which varies from 20.37 to 22.40 cm.

The treatment differed significantly for plant spread at 60 days after transplanting and it was observed in the range 22.10 cm to 25.23 cm. The treatment GA_3 at 200 ppm (T_2) continued to grow with a widest canopy of 25.23 cm spread, which was on far with GA_3 at 100 ppm (24.46 cm). The least plant spread (22.10 cm) was observed in control (T_9).

Table 7. Influence of different plant growth regulators on plant spread North – South (cm) at different stages of crop growth

Treatment details	Plant spread North – South (cm) at different DAT					
	30	**60**	**90**	**120**	**150**	**180**
T_1- $GA_{3\ @}$ 100 ppm	21.43	24.46	27.30	30.36	37.36	44.15
T_2- GA_3 @200 ppm	22.40	25.23	28.13	32.78	40.44	46.19
T_3-NAA @100 ppm	21.03	23.57	26.30	29.24	36.83	42.94
T_4-NAA @150 ppm	20.93	23.73	26.40	28.28	35.82	42.16
T_5-TIBA @100 ppm	20.88	23.53	26.17	27.82	35.62	41.45
T_6-TIBA @150 ppm	20.37	23.70	26.23	28.09	35.76	41.15
T_7- Ethrel @50 ppm	20.83	22.31	25.53	27.19	35.39	41.48
T_8-Ethrel @100 ppm	20.50	22.50	25.40	27.40	35.17	40.88
T_9-Control	20.90	22.10	24.00	26.84	32.50	37.53
S. Em (±)	0.37	0.39	0.49	0.58	0.72	0.54
CD at 5 %	NS	1.18	1.48	1.76	2.18	1.63

DAT: Days after transplanting**;** **NS:** Non significant

There was significant difference in the plant spread among the treatment at 90 days after transplanting. Plant spread was recorded in the range of 24.00 cm to 28.13 cm. The treatment GA_3 at 200 ppm had the maximum plant spread (28.13 cm), which was on far with GA_3 at 100 ppm (27.30 cm). The least plant spread (24 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 120 days after transplanting. Plant spread was recorded in the range of 24.84 cm to 32.78 cm. The treatment GA_3 at 200 ppm (32.78 cm) had the maximum plant spread. The least plant spread (26.84 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 150 days after transplanting. Plant spread was recorded in the range of 32.50 cm to 40.44 cm. The treatment GA_3 at 200 ppm (T_2) had the maximum plant spread (40.44 cm). The least plant spread (32.50 cm) was observed in control (T_9).

There was significant difference in the plant spread among the treatment at 180 days after transplanting. Plant spread was recorded in the range of 37.53 cm to 46.19 cm. The treatment GA_3 at 200 ppm (T_2) recorded maximum plant spread (46.19 cm) and the least plant spread (37.53 cm) was observed in control (T_9).

4.1.1.7 Chlorophyll estimation (mg/g)

The data pertaining to chlorophyll content in different treatment are presented in Table 8.

The treatment GA_3 at 100 ppm (T_1) had significantly higher chlorophyll ‘a’(1.53 mg/g) content and it was on par with NAA at 150 ppm (1.45 mg/g) and TIBA at 150 ppm (1.47 mg/g). The chlorophyll ‘a’ content was minimum in the treatment ethrel at 50 ppm (1.14 mg/g).

Chlorophyll ‘b’ content was highest in the treatment GA_3 at 100 ppm (0.65 mg/g) which was on par with NAA at 150 ppm (0.61 mg/g) and TIBA at 150 ppm (0.60 mg/g). Lowest chlorophyll ‘b’ content was observed in the treatment control (0.37 mg/g).

Table 8. Influence of different plant growth regulators on carotinoid, chlorophyll "a", chlorophyll "b' and total chlorophyll (mg/g)

Treatment details	Carotenoid	Chlorophyll "a"	Chlorophyll "b"	Total chlorophyll
T_1- GA_3 @ 100 ppm	2.56	1.53	0.65	2.18
T_2- GA_3 @200 ppm	2.09	1.16	0.55	1.71
T_3-NAA @100 ppm	2.41	1.42	0.56	1.98
T_4-NAA @150 ppm	2.51	1.45	0.61	2.06
T_5-TIBA @100 ppm	2.07	1.32	0.51	1.83
T_6-TIBA @150 ppm	1.95	1.47	0.60	2.07
T_7- Ethrel @50 ppm	2.01	1.14	0.49	1.63
T_8-Ethrel @100 ppm	1.95	1.20	0.50	1.70
T_9-Control	2.42	1.27	0.37	1.64
S. Em (±)	0.06	0.03	0.02	0.016
CD at 5 %	0.20	0.09	0.06	0.05

Total chlorophyll content was recorded highest in treatment GA_3 at 100 ppm (2.18 mg/g). Lowest total chlorophyll content was observed in the treatment ethrel at 50 ppm and control (1.63 mg/g).

4.1.1.8 Carotinoid content (mg/g)

The data pertaining to carotinoid content in different treatment of growth regulators are presented in Table 8.

The treatment GA_3 at 100 ppm (T_1) had significantly higher carotinoid (2.56 mg/g) content which was on par with treatment NAA at 100 ppm (2.41 mg/g), NAA at 150 ppm (2.51 mg/g) and control (2.42 mg/g) and it was minimum in the treatment TIBA at 150 ppm and ethrel at 100 ppm (1.95 mg/g).

4.1.1.9 Dry matter of whole plant (g)

Treatments differ significantly for the dry matter of whole plant is presented in Table 5 .The treatment GA_3 at 200 ppm (T_2) was showed maximum dry matter (88.85 g). The treatment NAA at 100 ppm (38.59 g) was showed minimum dry matter of whole plant.

4.1.2 Flowering attributes

Data pertaining to flowering parameters like days taken to first flower bud initiation, days taken to first harvest and duration of flowering after bending are furnished in Table 9.

4.1.2.1 Days taken to flower spike initiation

Treatments differ significantly for the days required to first flower spike initiation. The treatment GA_3 at 100 ppm (T_1) was early to show its visible flower spike in 38.00 days after transplanting, which was on par with GA_3 at 200 ppm (40.67 DAT), ethrel at 50 ppm (42.33 DAT) and ethrel at 100 ppm (T_8) (42.67 days after transplanting). The treatment control (T_9) (46 DAT) was late to initiate flower spike.

Table 9. Influence of different plant growth regulators on flower spike initiation, first harvest and flower duration

Treatment details	Flower spike initiation	Days taken to first harvest	Flower duration
T_1- GA_3 @ 100 ppm	38.00	53.00	122.67
T_2- GA_3 @200 ppm	40.67	55.67	131.00
T_3-NAA @100 ppm	45.33	60.33	121.33
T_4-NAA @150 ppm	45.10	60.40	117.33
T_5-TIBA @100 ppm	44.67	59.67	117.67
T_6-TIBA @150 ppm	45.67	60.33	119.33
T_7- Ethrel @50 ppm	42.33	57.33	117.67
T_8-Ethrel @100 ppm	42.67	57.67	119.33
T_9-Control	46.00	61.95	112.00
S. Em (±)	1.63	0.09	1.94
CD at 5 %	4.89	0.27	5.82

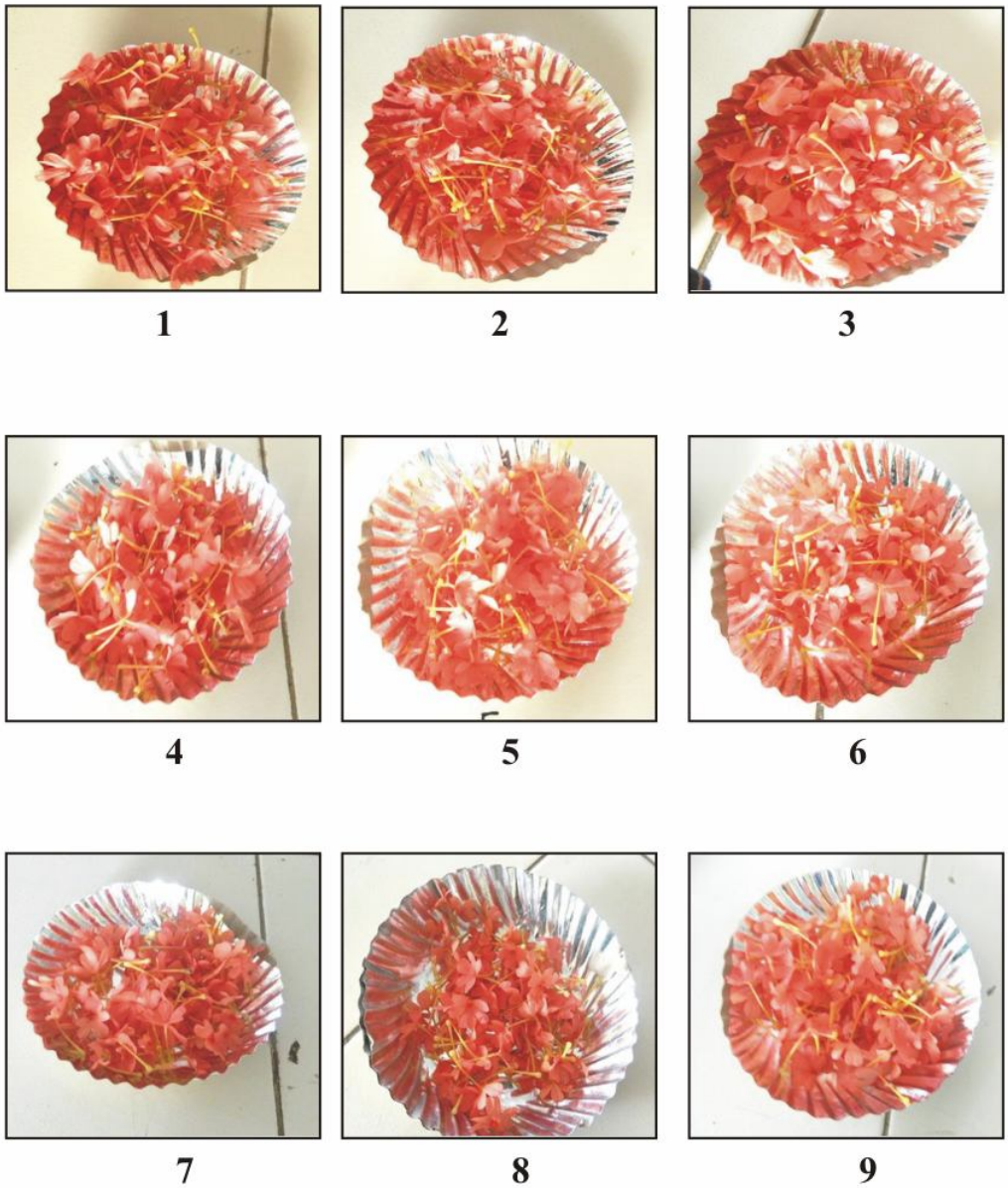

Plate 3: Influence of growth regulators on shelf life of crossandra flowers

4.1.2.2 Days taken to first harvest

The treatments differ significantly for days taken to first harvest. The treatment GA_3 at 100 ppm (T_1) was early to harvest in 53.00 days after transplanting and control (T9) shown late to harvest the flowers (61.95 DAT).

4.1.2.3 Duration of flowering

Results revealed that the significant variation among the treatments of different growth regulator treatments for duration of flowering. Flower duration period was maximum in the treatment GA_3 at 200 ppm (131 days) and it was minimum in control (112 days).

4.1.3 Yield and other parameters

The data pertaining yield and other parameters like number of flowers per spike, number of spikes per plant, 100 flowers weight, flower yield per plant, flower yield per plot and flower yield per hectare are presented in Table 11.

4.1.3.1 Number of flowers per spike

Results revealed a significant variation among the use of different growth regulators for number of flowers per spike. Production of flower per spike was maximum (52.30) in T_2 (GA_3 at 200 ppm) which was found superior over all the treatment while, flowers per spike production was minimum (48.00) in the control.

4.1.3.2 Number of spikes per plant

Data pertaining to number of spikes per plant of different treatment of growth regulators is presented in Table 10.

There was significant difference in the number of spikes per plant among the treatment at 60 days after transplanting. Number of spikes per plant was recorded in the range of 13.91 to 17.59. The treatment GA_3 at 200 ppm (17.59) had the maximum number of spikes per plant. The least number of spikes per plant was observed in control (13.91).

Table 10. Influence of different plant growth regulators on number of spikes per plant

Treatment details	Number of spikes/plant at different DAT				
	60	**90**	**120**	**150**	**180**
T_1- $GA_{3\ @}$ 100 ppm	16.15	27.75	35.42	37.54	38.70
T_2- GA_3 @200 ppm	17.59	29.18	36.57	37.95	40.03
T_3-NAA @100 ppm	15.34	25.80	32.14	35.75	38.31
T_4-NAA @150 ppm	14.19	22.20	30.66	35.20	38.54
T_5-TIBA @100 ppm	14.83	23.60	30.43	34.25	38.62
T_6-TIBA @150 ppm	14.59	21.27	30.16	34.26	38.52
T_7- Ethrel @50 ppm	14.87	21.53	29.86	35.17	38.29
T_8-Ethrel @100 ppm	15.48	22.07	29.74	34.01	38.27
T_9-Control.	13.91	20.93	27.55	34.41	38.23
S. Em (±)	0.36	0.75	0.68	0.86	0.27
CD at 5 %	1.09	2.27	2.06	2.59	0.81

DAT: Days after transplanting**;** **NS:** Non significant

There was significant difference in the number of spikes per plant among the treatment at 90 days after transplanting. Number of spikes per plant was recorded in the range of 20.93 to 29.18. The treatment GA_3 at 200 ppm (29.18) observed the maximum number of spikes per plant, which was on par with GA_3 at 100 ppm (27.75). The least number of spikes per plant (20.93) was observed in control.

There was significant difference in the number of spikes per plant among the treatment at 120 days after transplanting. Number of spikes per plant was recorded in the range of 27.55 to 36.57. The treatment GA_3 at 200 ppm (36.57) was recorded the maximum number of spikes per plant, which was on par with GA_3 at 100 ppm (T_1) (35.42). The least number of spikes per plant (27.55) was observed in control (T_9).

There was significant difference in the number of spikes per plant among the treatment at 150 days after transplanting. Number of spikes per plant was recorded in the range of 34.01 cm to 37.95. The treatment GA_3 at 200 ppm (37.95) showed the maximum number of spikes per plant, which was on far with GA_3 at 100 ppm (37.54) and NAA at 100 ppm (T_3) (35.75). The least number of spikes per plant was observed in ethrel at 100 ppm (34.01).

There was significant difference in the number of spikes per plant among the treatment at 180 days after transplanting. Number of spikes per plant was recorded in the range of 38.23 to 40.03. The treatment GA_3 at 200 ppm (40.03) had the maximum number of spikes per plant. The least number of spikes per plant (38.23) was observed in control (T_9).

4.1.3.3 100 Flowers weight

For the parameter 100 flowers weight varied significantly among the different growth regulators treatment. The maximum (4.13 g) 100 flower weight was observed in T_2 (GA_3 at 200 ppm) which was on par with T_1 (GA3 at 100 ppm) (4.10 g). The lowest 100 flower weight (3.85 g) was recorded in the T_9 (control).

4.1.3.4 Flower yield per plant

Treatments differ significantly for flower yield per plant. The treatment T_2 (GA_3 at 200 ppm) recorded maximum (82.60 g) flower yield per plant and it was minimum (70.31. g) T_9 (control).

Table 11. Influence of different plant growth regulators on flowers per spike, 100 flower weight, flower yield per plant, flower yield per plot and flower yield per hectare

Treatment details	Flowers per spike	100 flower wt (g)	Flower yield per plant (g)	Flower yield per plot (g)	Flower yield per hectare (t/ha)
T_1- GA_3@ 100 ppm	50.00	4.10	78.43	1175.99	4.35
T_2- GA_3 @200 ppm	52.30	4.13	82.60	1238.34	4.56
T_3-NAA @100 ppm	48.59	3.90	72.61	1087.32	4.03
T_4-NAA @150 ppm	48.39	3.91	72.96	1096.25	4.05
T_5-TIBA @100 ppm	48.22	3.92	71.54	1073.43	3.97
T_6-TIBA @150 ppm	48.05	3.86	71.00	1064.52	3.94
T_7- Ethrel @50 ppm	48.04	3.89	70.60	1058.93	3.92
T_8-Ethrel @100 ppm	48.12	3.86	70.75	1061.40	3.93
T_9-Control	48.00	3.85	70.31	1056.58	3.90
S. Em (±)	0.49	0.03	1.37	2.64	0.05
CD at 5 %	1.49	0.09	4.12	7.92	0.17

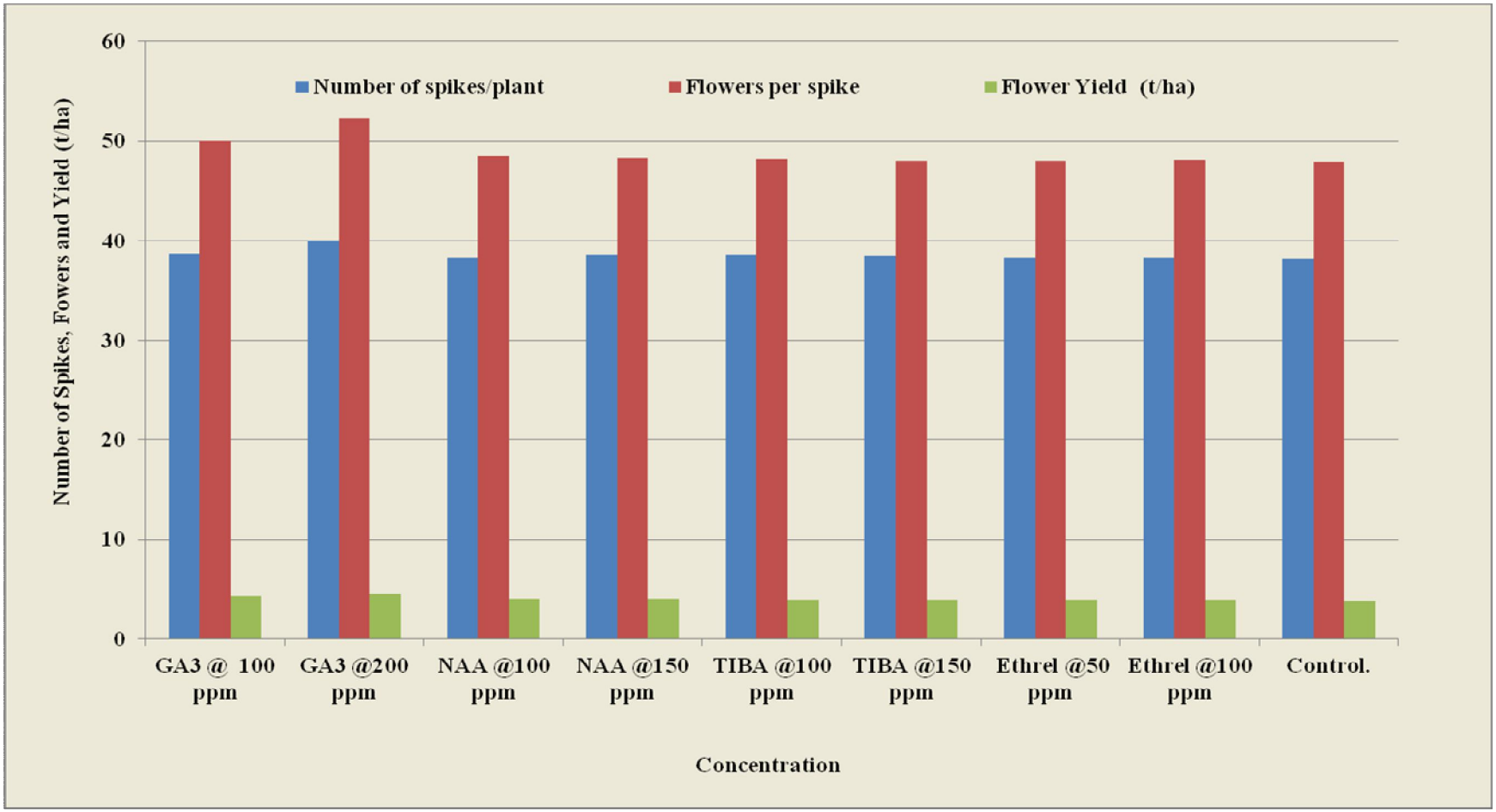

Fig. 3: Influence of different plant growth regulators on number of spikes per plant, number of flowers per spike and flower yield per hectare (t/ha)

Table 12. Influence of different plant growth regulators on flower diameter, corolla length and shelf life

Treatment details	Corolla length (mm)	Flower diameter (mm)	Shelf life (days)
T_1- GA_3 @100 ppm	27.53	27.33	3.26
T_2- GA_3 @200 ppm	28.42	28.23	3.37
T_3-NAA @100 ppm	26.21	25.48	3.07
T_4-NAA @150 ppm	26.33	25.53	2.86
T_5-TIBA @100 ppm	26.21	25.88	2.75
T_6-TIBA @150 ppm	25.59	25.29	2.75
T_7- Ethrel @50 ppm	25.33	24.55	2.44
T_8-Ethrel @100 ppm	25.76	25.47	2.29
T_9-Control	25.20	24.13	2.47
S. Em (±)	0.3	0.44	0.07
CD at 5 %	0.9	1.32	0.21

4.1.3.5 Flower yield per plot

There was significant difference for flower yield per plant. The treatment T_2 (GA_3 at 200 ppm) recorded maximum flower yield per plant (1238.34 g) and it was superior over all the treatment. The minimum flower yield per plant (1056.58 g) was recorded in the T_9 (control).

4.1.3.6 Flower yield per hectare

Application of different growth regulators influenced the flower yield per hectare. The treatment T_2 (GA_3 at 200 ppm) noticed maximum (4.56 t/ha) flower yield per hectare. The minimum (3.90 t/ha) flower yield per hectare was recorded in the control.

4.1.3.7 Incidence of pest and disease

4.1.3.7.1 Incidence of insect pest

There was no serious pests (Aphids, Scales and whitefly) found during the experimental period.

4.1.3.7.2Wilt

There was no serious wilt occur in my research field.

4.1.4 Quality parameters

The data on flower diameter, corolla length and shelf life are presented in Table 12.

4.1.4.1 Flower diameter

The flower diameter differed significantly among the different growth regulators which ranged from 24.13 mm to 28.23 mm. Among the treatments, maximum (28.23 mm) flower diameter was recorded in T_2 (GA_3 at 200 ppm) which was on par with T_1 (GA_3 at 100 ppm) (27.33 mm). Whereas, the minimum (24.13 mm) flower diameter was recorded in the T_9 (control).

4.1.4.2 Corolla length

Treatments differed significantly with respect to corolla length due to use of different growth regulators and it was ranges from 25.20 mm to 28.42 mm. Among treatments, T_2 (GA_3 at 200 ppm) recorded significantly maximum corolla length of 28.42 mm which was on par with T_1 (GA_3 at 100 ppm) (27.53 mm). The lowest corolla length was observed in control (25.20 mm).

4.1.4.3 Shelf life (Days)

Treatments differed significantly with respect to shelf life which ranges from 2.29 to 3.37 days. Among growth regulator treatments, T_2 (GA_3 at 200 ppm) recorded significantly maximum shelf life of 3.37 days which was on par with T_1 (GA_3 at 100 ppm). The lowest shelf life of 2.29 days was observed in the T_8 (ethrel at 100 ppm).

4.1.4.4 Physiological loss in weight (%)

The data pertaining to physiological loss in weight for different treatments are presented in Table 13. During the entire period of storage *viz.*, 24, 48 and 72 hours the physiological loss in weight of crossandra flowers was recorded and it was found to be minimum (19.65 per cent) in GA_3 at 200 ppm (after24 hour), which was on par with GA_3 at 100 ppm (21.46 %), NAA at 100 ppm (22.43 %) and NAA at 150 ppm (23.48 %). The maximum physiological loss was 30.53 per cent in ethrel at 100 ppm (T_8) after 24 hours.

The physiological loss in weight of crossandra flowers was recorded and it was found to be minimum 40.48 per cent in GA_3 at 200 ppm (after 48 hour), which was on par with GA_3 at 100 ppm (41.67 %) and TIBA at 150 ppm (44.53 %). The maximum physiological loss was 53.17 per cent found in ethrel at 100 ppm (T_8) after 48hour.

The physiological loss in weight of crossandra flowers was found non-significant at 72 hrs.

4.1.5 B: C Ratio

The data pertaining to B: C ratio in different treatments is presented in Table 14. Among the different treatments, GA_3 at 200 ppm was given maximum B: C ratio (2.62) followed by GA_3 at 100 ppm (2.51) and minimum B: C ratio (2.26) was in control.

Table 13. Influence of different plant growth regulators on Physiological loss in weight

Treatment details	Initial weight of flowers	Physiological loss in weight (%)		
		After 24 hrs	After 48 hrs	After 72 hrs
T_1- GA_3 @100 ppm	4.90	21.46	41.67	61.50
T_2- GA_3 @200 ppm	4.22	19.65	40.48	60.92
T_3-NAA @100 ppm	4.86	22.43	45.54	61.76
T_4-NAA @150 ppm	4.51	23.48	47.48	64.99
T_5-TIBA @100 ppm	4.08	27.46	47.88	65.23
T_6-TIBA @150 ppm	4.13	26.35	44.53	67.36
T_7- Ethrel @50 ppm	3.98	29.28	51.89	69.36
T_8-Ethrel @100 ppm	3.49	30.53	53.17	69.08
T_9-Control	4.12	30.21	46.38	65.46
S. Em (±)	0.03	1.68	1.67	2.55
CD at 5 %	0.09	5.04	5.01	NS

NS: Non significant

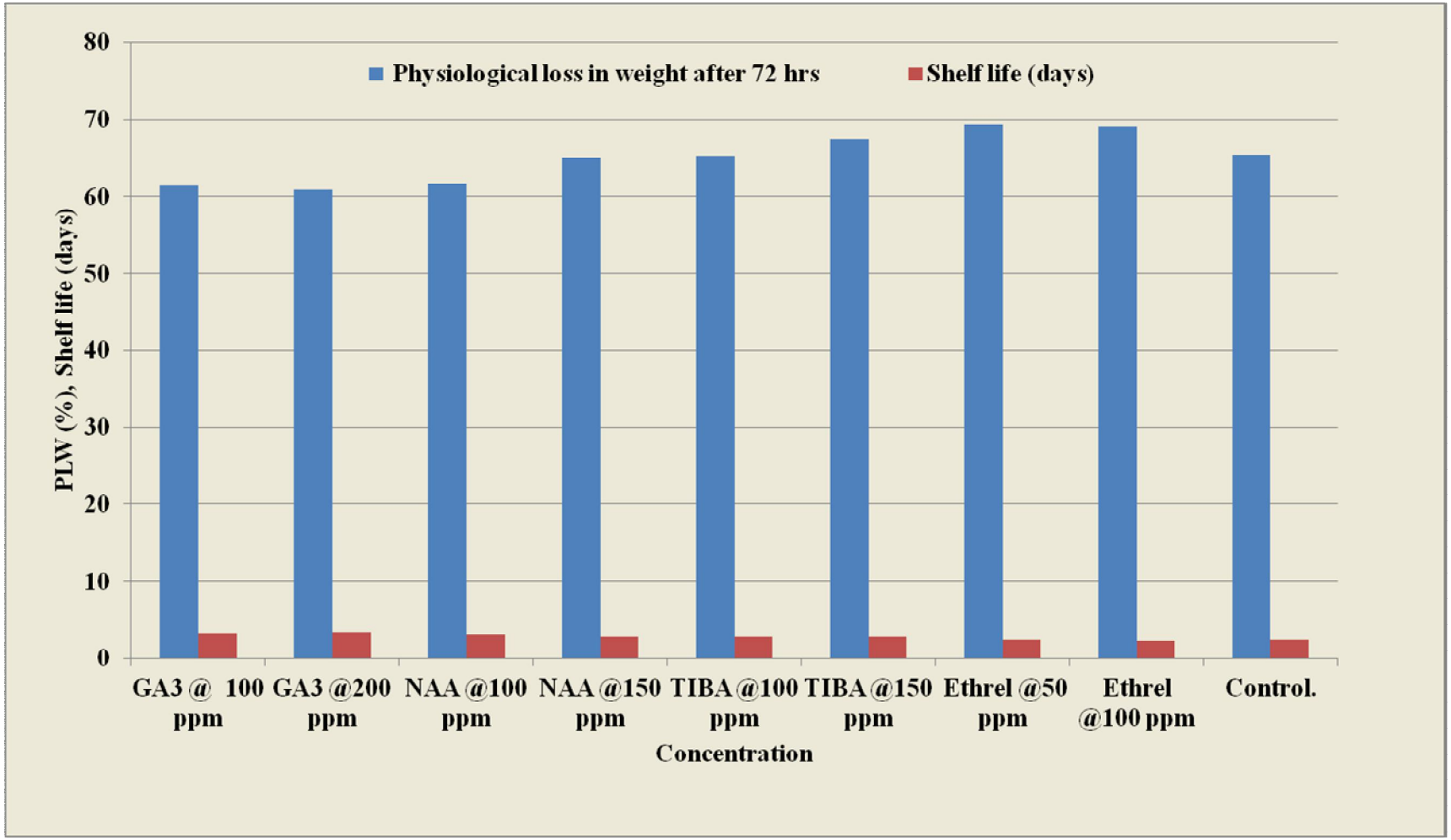

Fig. 4: Influence of different plant growth regulators on physiological loss in weight (after 72 hours) and shelf life (days)

Table 14. Economics with cost benefit ratio for commercial cultivation of crossandra genotype ACC-1.

Particulars	GA3 (100 ppm)	GA3 (200 ppm)	NAA (100 ppm)	NAA (150 ppm)	TIBA (100 ppm)	TIBA (150 ppm)	Ethrel (50 ppm)	Ethrel (100 ppm)	Control
Site cleaning	1000	1000	1000	1000	1000	1000	1000	1000	1000
Land preparation	3000	3000	3000	3000	3000	3000	3000	3000	3000
Planting material	277775	277775	277775	277775	277775	277775	277775	277775	277775
Transplanting	2000	2000	2000	2000	2000	2000	2000	2000	2000
FYM	20000	20000	20000	20000	20000	20000	20000	20000	20000
NPK	9700	9700	9700	9700	9700	9700	9700	9700	9700
Weeding	10000	10000	10000	10000	10000	10000	10000	10000	10000
Irrigation	2000	2000	2000	2000	2000	2000	2000	2000	2000
Miscellaneous	4000	4000	4000	4000	4000	4000	4000	4000	4000
Harvesting	15000	15000	15000	15000	15000	15000	15000	15000	15000
Growth regulator	1350	2700	908	1365	1666.6	2499.7	250	500	-
Yield	4350	4560	4030	4050	3970	3940	3920	3930	3900
Return	870000	912000	806000	810000	794000	788000	784000	786000	780000
Net return	524175	564825	460617	464160	447858.4	441025.3	439275	441025	435525
B:C ratio	2.51	2.62	2.33	2.34	2.29	2.27	2.27	2.27	2.26
Total cost	345825	347175	345383	345840	346141.6	346974.7	344725	344975	344475

5. DISCUSSION

In any crop production programme, the flower yield and quality parameters are directly or indirectly controlled by environment under which crops are grown. In addition, genotype, soil, cultural practices and their interactions also have profound influence on productivity of crop plants. However, it is, not possible to manipulate the environment for better crop growth, but one can manipulate the micro climate of the field to certain extent by adopting suitable cultural practices. Hence an attempt was made to increase the yield and quality of flowers by manipulating cultivation practices like pinching and application of growth regulators and to study their effect on yield and flower quality of crossandra.

The objective of the present study is to increase the flower yield by manipulating the growth of the plant and to improve the flower quality by using various plant growth regulators. The present investigation was undertaken at the experimental unit of Department of Floriculture and Landscape Architecture, Kittur Rani Channmma College of Horticulture, Arabhavi to assess the effect of plant growth regulator on growth, flowering, yield and quality parameters of crossandra.

The experiment was carried out during the period from June 2015 to February 2016. Findings of the present investigation were discussed under the following headings with supporting data and available literature.

5.1 Growth parameters

5.2 Flowering parameters

5.3 Yield parameters

5.4 Flower quality parameters

5.5 Pest and disease incidence

5.6 B:C ratio

5.1 Growth parameters

Vegetative growth is best measured in terms of plant height, stem girth, plant spread, number of leaves, number of suckers, leaf area, dry matter production and chlorophyll content.

5.1.1 Plant height

Basically, plant height is genetically controlled character but several studies have indicated that plant height can be either increased or decreased by the application of synthetic growth regulators (Talukdar and Paswan, 1998 and Kulkarni, 2003) in chrysanthemum.

In the present study there were significant differences for plant height with different growth promoter treatments at different growth stages of crossandra. The application of GA_3 at 200 ppm alone produced maximum plant height. Wherein, GA which is growth promoters might have helped in accelerating cell division and enlargement as reported by Mandava (1988) These results are in confirmation with that of Binisundar *et al*. (2008) in crossandra. The enhanced cell division, cell enlargement and promotion of protein synthesis by GA application exogenously, might have resulted in enhanced vegetative growth as reported by Girish (2012) in daisy.

5.1.2 Stem girth

Stem girth varied significantly for different growth promoters in all crop stages. Thick stem girth was in GA_3 treated plants, followed by plants treated with NAA and TIBA. Whereas, thinnest stem girth was observed in control. Stem girth found to be maximum due to the fact that GA and NAA are known to influence cell enlargement and cell division. Similar results were observed by Gautam *et al.* (2006) in chrysanthemum and Bhattacharjee *et al.* (1984) in dahlia.

5.1.3 Number of branches

Maximum number of branches was recorded in application of GA and NAA (100 ppm). Stimulation of branching may be attributed to the breakage of apical dominance. Similar results were reported by Binisundar *et.al*. (2008) in crossandra, Lal

and Mishra (1986) in aster and marigold, Shetty (1995) and Doddagoudar (2002) in China aster and. Padmapriya and Chezhiyan (2003) in chrysanthemum and Amit *et al*. (2011) in African marigold

5.1.4 Plant spread

Maximum plant spread was recorded in application of GA and NAA (100 ppm). GA is known to influence the cell elongation, enlargement primary and secondary branches (vegetative growth) which in turn influence the plant spread (Kulkarni, 2003). Similar findings were noticed by Shinde *et al.* (2010) in chrysanthemum. Gautam *et al.* (2006) in chrysanthemum.

5.1.5 Leaf area per pant

Leaf area was significantly influenced by growth promoters at different stages of plant growth. The leaf area was maximum in GA followed by TIBA. Similarly, Binisundar *et al.* (2008) observed maximum leaf area in plants sprayed with GA_3 200 ppm. The increase in leaf area might be due to production of more number of leaves of maximum length and leaf width as reported by Nandre *et al.* (2009) in china aster and Sharma *et al.* (2006) in gladiolus.

5.1.6 Dry matter production

Significant influence on dry matter production by different growth promoters in all crop stages was observed. Profuse dry matter was produced in the plants sprayed with the application of GA at lower concentrations. Whereas, lowest dry matter production was noticed in control plants .It is due to the fact that the plants treated with GA had increased leaf area which might have facilitated the accumulation of more carbohydrates in terms of increased dry matter production. Maximum dry matter production was recorded in crossandra reported by Binisundar *et al.* (2008) and Nandre *et al.* (2009) in china aster.

5.1.7 Chlorophyll content and carotenoid content

Chlorophyll is the main source of photosynthesis which was influenced by growth promoters. In the present study maximum chlorophyll contents were noticed in

the plants sprayed with the application of GA due to more absorption of nutrients from the field which in terms produce more branch and more green leaves, followed by NAA in various crop periods. Increased total chlorophyll content in Marigold has reported by Azzaz *et al*. (2007). Rani *et al*. (2015) in gladiolus Similarly, Girish *et al.* (2012) recorded influenced effect on chlorophyll contents in leaf by using GA in daisy. More carotenoid content was observed in GA treatments, carotenoids amount in leaves that resulted in increase in plant height, leaf number and their width or area fort rapping more sunlight and prevent breakdown of chlorophyll and other pigments. Rani *et al*. (2015) in gladiolus.

5.2 Flowering parameters

5.2.1 Days taken to flower spike initiation

In general the plants treated with GA were early to produce first flower than control plants. This might be due the effect of gibberellins, as gibberellins influences florigen which requires for formation of flowers which leads to early harvesting of flowers and enhance flowering duration. These results are in accordance with Binisundar *et al*. (2008) in crossandra, Girish *et al*. (2012) in daisy and Doddagoudar *et al.* (2004) in China aster.

5.3 Yield parameters.

At proper concentration, the plant growth hormones are known to manipulate growth and flowering in desirable direction. In this study, the application of GA produced profuse spikes per plant. It might be due to the production of optimum plant stature, increased number of branches, leaves, leaf area and plant spread, which in turn enabled them to produce increased amount of photosynthesis ultimately resulting in accumulation of maximum dry matter, increased flower duration, yield and quality. Similar findings were also reported by Binisundar *et al*. (2008) in crossandra, Kulkarni (2003) in chrysanthemum, Talukdar and Paswan (1996) in chrysanthemum by using GA.

GA_3 at 200 ppm spray recorded significantly higher values for all yield parameters followed by GA_3 at 100 ppm compared to control.

In this study, GA_3 at 200 ppm produced profuse flowers per plant. This might be due to the production of optimum plant stature, increased number of branches, leaf area and plant spread, which in turn enabled them to produce increased amount of photosynthesis, ultimately resulting in accumulation of maximum dry matter, increased flower duration, yield and quality. Similar findings were also reported by Kulkarni (2004) in chrysanthemum. Talukdar and Paswan (1996) in chrysanthemum by using GA. The increase in yield and yield parameters with GA_3 at 200 ppm spraying was due to enhanced reproductive efficiency and photosynthesis in restructured plant type produced more number of flowers per plant and ultimately increased the flower yield per plot. This can be attributed to translocation of source to sink. Similar results were reported by Binisundar *et al.* (2008) in crossandra, Shetty (1995) and Doddagoudar *et al* (2004) in China aster and Prabhatkumar *et al*. (2003) in China aster.

5.4 Flower quality parameters

In this study flower quality parameters like flower diameter, corolla length and shelf life was varied significantly due to various growth promoters. Flower quality parameters were maximum in the plants sprayed with application of GA.

Enhancement of flower size due to growth promoters could be attributed to increased length of petals,that the enlargement of flower size is caused by drawing photosynthates to the flowers as a consequence of intensification of sink. These results also in confirmation with the findings of Binisundar *et al*. (2008) in crossandra, Talukdar and Paswan (1996) and Kulkarni (2003) in chrysanthemum.

Shelf life was varied significantly with different growth promoters. The maximum shelf life and minimum physiological loss in weight was noticed in application of GA in different crop periods. This enhanced Shelf life of flower stalks treated by GR might be due to the enhanced efficiency of plants and better mobilization of metabolites under direction of growth substance by Akalde *et al*. (2010) in chrysanthemum. Ramdevaputra *et al.* (2009) in african marigold. Chandrappa *et al*. (2006) in anthurium.

5.5 Pest and disease incidence

Pest and disease incidence did not cause any significant damage to the crop, because periodical management practices are fallowed.

5.6 B:C ratio

The highest B:C ratio was found in treatment GA_3 at 200 ppm followed by GA_3 at 100 ppm , all other treatments shown more B:C ratio as compared to Ethrel and control. .

Future line of work

1. In view of the best response of the crop to GA, various concentrations of GA and its synergism can be tried.

2. The organic extracts like vermiwash, biogas slurry and other plant extracts can be used to improve the growth, yield and quality of flowers as they are known to influence the growth of plants.

3. Influence of different growth promoters and growth retardants need to be studied.

6. SUMMARY AND CONCLUSIONS

Present investigation on “Studies on effect of plant growth regulators on growth, flowering and yield of crossandra (*Crossandra undulaefolia* Salisb) genotype ACC-1” was carried out in the experimental field of the Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi during June, 2015 to February, 2016. The experiment was conducted in Randomized Completely Block Design (RCBD) having 9 treatments with 3 replications. Different growth regulators like GA at 100 and 200 ppm , NAA at 100 and 150 ppm,, TIBA at 100 and 150 ppm finally Ethrel at 50 and 100 ppm were sprayed at 15 days interval *viz.*, 15, 30, 45 and 60 DAT and control plants were sprayed with water. The main objective of the study was to know the effect of growth regulators in increasing the growth, yield and quality attributes in crossandra genotype ACC-1. The salient features of the experimental findings were summarized below.

6.1 Growth parameter

The growth parameters like plant height, stem girth, plant spread, number of branches and leaf area in crossandra genotype ACC-1 were differed significantly due to different growth regulators.

The plant height was significantly influenced by application of GA at high concentration (100 and 200 ppm) and NAA at higher concentration (100 and 150 ppm) found next best treatment. While, control plants had minimum plant height during different stages of crop periods.

The stem girth found to be thicker in plants sprayed with GA followed by NAA, whereas, thinnest stems were in control plants.

The plant spread was found to be the highest in plants sprayed with application of GA, followed by NAA. While, control plants recorded minimum plant spread in East-West and North South.

The leaf area was maximum in the treatment application of GA in all crop growth stages and all crop periods, whereas, control produced minimum leaf area per plant.

6.2 Flowering parameters

The days to first flowering was significantly influenced by different growth promoters. Early flowering was noticed in the plants sprayed with GA at high concentrations in all crop periods. While NAA at higher concentration found as next best treatment. While, delayed flowering was observed in control plants.

Days taken to first harvest, the minimum days taken for flower harvesting was observed in GA treated plants as compared to control.

The plants sprayed with GA at higher concentrations took longer flower duration was found while, minimum duration of flowering was found in control.

6.3 Yield parameters

The yield is a potentially genetic character and it is greatly influenced by growth regulators. The number of spikes per plant and number of flowers per spike varied significantly and it was found to be maximum in plants sprayed with the GA at higher concentrations in different growth stages of crop while, lower spike yield was recorded in control plants.

The maximum flower yield per plant, per plot and per hectare was obtained by spraying with the GA at higher concentrations in different growth stages of crop while, lower flower yield was recorded in control plants.

6.4 Spike and flower quality parameters

The spike and flower quality parameters corolla length, physiological loss in weight flower diameter and shelf life varied significantly due to different growth promoters.

The larger flower diameter, longer corolla length and longer shelf life were observed in plants sprayed with GA at higher concentration whereas; lowest values were noticed in control plants.

6.5 Physiological observations

The physiological parameters like chlorophyll, carotinoid and dry matter were found maximum at GA sprayed treatment compared to other treatments.

6.6 Pest and disease incidence

Growth regulators did not influence on disease incidence. Minor disease observed was wilt, which was suspected to be caused by fungus like organisms, require further study for confirmation.

6.7 B:C ratio

B:C ratio was highest in plants sprayed with GA_3 at 200 ppm as compared to other treatments .

Conclusion

The experiment can be concluded that spraying of plants with GA_3 at 200 ppm improves the growth, yield, quality and higher B:C ratio of crossandra genotype ACC-1 and this growth regulator was evolved as suitable growth regulators in order to get good quality results.

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Appendix I: Meteorological data recorded for experimental period (2015-16) at Agriculture Research Station, Arabhavi

Month	Temperature ^{o}C		Relative humidity (%)	Rain fall (mm)
	Minimum	Maximum		
June 2015	21.20	31.40	85.50	69.50
July 2015	20.70	31.10	84.50	7.90
August 2015	19.90	30.90	88.30	33.70
September 2015	18.90	31.90	89.40	53.70
October 2015	18.30	34.60	89.90	53.30
November 2015	14.30	30.90	87.00	30.90
December 2015	19.00	28.00	90.00	28.00
January 2016	10.40	31.50	88.90	0.00
February 2016	14.50	35.90	91.70	0.00

EFFECT OF GROWTH REGULATORS ON GROWTH, FLOWERING AND YIELD OF CROSSANDRA (*Crossandra Undulaefolia* Salisb) GENOTYPE ACC-1

ARABANNA PUJERI **2016** **Mr. BASAPPA KAMBLE**
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ABSTRACT

The study was conducted at the Department of Floriculture and Landscape Architecture Kittur Rani Channamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot, during *kharif* and *rabi* season from June, 2015 to February, 2016, to know the influence of foliar spray of plant growth regulators on growth, flowering and yield of crossandra (*Crossandra undulaefolia* Salisb) genotype ACC-1. The experiment was laid out by adopting Randomized Completely Block Design (RCBD), having nine treatments with three replications. The treatments were comprised of two concentrations of Gibberellic acid (100 and 200 ppm), NAA (100 and 150 ppm), TIBA (100 and 150 ppm), Ethrel (50 and 100 ppm) and control (water spray). The plant growth regulators were sprayed four times *viz.*, 15, 30, 45 and 60 days after transplanting.

Among the growth regulators the plants sprayed with the Gibberellic acid (200 ppm) resulted significantly maximum plant height, number branches per plant, plant spread, leaf area, dry weight. While, the yield and quality parameters like days taken to flower spike initiation, days taken to first harvest,duration of flowering, flower diameter, number of flowers per inflorescence, number of spikes per plant, 100 flower weight, flower yield per plant, flower yield per plot, flower yield per hectare, chlorophyll and carotinoid estimation, shelf life, corollar length and physiological loss in weight were also observed in plants sprayed with the Gibberellic acid (200 ppm).

ಕನಕಾಂಬರದ ಎಸಿಸಿ-1 ತಳಿಯ ಬೆಳವಣಿಗೆ, ಹೂವಾಡುವಿಕೆ ಮತ್ತು ಇಳುವರಿಯ ಮೇಲೆ ಸಸ್ಯ ಪ್ರಚೋದಕಗಳ ಪ್ರಭಾವದ ಅಧ್ಯಯನ

ಅರಬಣ್ಣ ಪೂಜೇರಿ **2016** **ಬಸಪ್ಪ ಕಾಂಬ್ಳೆ**
ಪ್ರಧಾನ ಸಲಹೆಗಾರರು

ಸಾರಾಂಶ

ಕಿತ್ತೂರ ರಾಣಿ ಚನ್ನಮ್ಮಾ ಮಹಾವಿದ್ಯಾಲಯ ಅರಭಾವಿಯಲ್ಲಿ, 2015-16 ನೇ ಸಾಲಿನಲ್ಲಿ ಕನಕಾಂಬರ ಹೂವಿನ ಎಸಿಸಿ-1 ತಳಿಯಲ್ಲಿ, ಗಿಡಗಳ ಬೆಳವಣಿಗೆ, ಹೂ ಬಿಡುವಿಕೆ ಮತ್ತು ಇಳುವರಿಯ ಮೇಲೆ ಬೆಳೆವಣಿಗೆಯ ನಿಯಂತ್ರಕಗಳ ಪ್ರಭಾವದ ಬಗ್ಗೆ ಅಧ್ಯಯನ ಕೈಗೊ¼Èಾಗಿತ್ತು. ಬೆಳೆವಣಿಗೆಯ ನಿಯಂತ್ರಕಗಳನ್ನು ವಿವಿಧ ಸಾಂದ್ರತೆಯಲ್ಲಿ ಸಿಂಪಡಿಸಿ ಅದರಿಂದ ಗಿಡಗಳ ಮೇಲಾಗುವ ಪ್ರಭಾವವನ್ನು ಅಭ್ಯಸಿಸಲಾಯಿತು. ಅಧ್ಯಯನವನ್ನು ಸಂಪೂರ್ಣಯಾದ್ರಿಚ್ಛಿಕ ವಿನ್ಯಾಸದಲ್ಲಿ M0ಭತ್ತು ಉಪಚಾರಗಳು ಮೂರು ಬಾರಿ ಪುಣರಾವರ್ತನೆಯಾಗುವಂತೆ ಅಳವಡಿಸಲಾಗಿತ್ತು. D ಒಂಭತ್ತು ಉಪಚಾರಗಳೆಂದರೆ, ಜಿಬ್ಬರಲಿಕ D¦¹ qï (100 ಮತ್ತು 200 ಪಿ. ಪಿ. ಎಮ್.), ಎನ್. J. J. (100 ಮತ್ತು 150 ಪಿ. ಪಿ. ಎಮ್.), ಟಿಬಾ (100 ಮತ್ತು 150 ಪಿ. ಪಿ. ಎಮ್.), ಇಥ್ರೇಲ್ (50 ಮತ್ತು 100 ಪಿ. ಪಿ. ಎಮ್.) ಮತ್ತು ನೀರಿನ ಸಿಂಪಡನೆ. F ಬೆಳವಣಿಗೆಯ ನಿಯಂತ್ರಕಗಳನ್ನು 15, 30, 45 ಮತ್ತು 60 ದಿನಗಳಿಗೆ ಒಮ್ಮೆಯಂತೆ ಒಟ್ಟು 4 ಬಾರಿ ಸಿಂಪಡಿಸಲಾಗಿತ್ತು.

ಪರೀಕ್ಷಿಸಿದ ಉಪಚಾರಗಳ ಪೈಕಿ ಜಿಬ್ಬರಲಿಕ್ D¦¹ qï (200 ಪಿ. ಪಿ. ಎಮ್.) ಸಿಂಪಡಣೆಯು ಗಿಡದ ಎತ್ತರ, ಕೊಂಬೆಗಳ ಸಂಖ್ಯೆ, ಸಸ್ಯದ ಪಸರಿಸುವಿಕೆ, ಎಲೆಯ ವಿಸ್ತೀರ್ಣ, ಒಟ್ಟು M t ಪದಾರ್ಥ ಮುಂತಾದ ಅಂಶಗಳಲ್ಲಿ ಉತ್ತಮ ಫಲಿತಾಂಶ ತೋರಿತ್ತು. ಅಲ್ಲದೆ ಹೂ ಬಿಡಲು ತೆಗೆದುಕೊಂಡ ದಿನಗಳ ಸಂಖ್ಯೆ, ಮೊದಲನೆ ಕೊಯ್ಲಿಗೆ ತೆಗೆದುಕೊಂಡ ದಿನಗಳ ಸಂಖ್ಯೆ, ಸರಾಸರಿ ಹೂವಾಡುವ ಅವಧಿ, ಹೂವಿನ ವ್ಯಾಸ, ಒಂದು ತೂರಾಯಿಯಲ್ಲಿನ ಹೂಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿಗಿಡಲ್ಲಿನ ಹೂಗೊಂಚಲುಗಳ ಸಂಖ್ಯೆ, 100 ಹೂಗಳ vÆP, ಪ್ರತಿ ಗಿಡದ ಇಳುವರಿ, ಪ್ರತಿ ತಾಕಿನ ಇಳುವರಿ, ಪ್ರತಿ ಹೇಕ್ಟರಿನ ಇಳುವರಿ, ಪತ್ರಹರಿತ್ತಿನ ಅಂಶ, ಕೆರೊಟಿನ್ಯೊಡ್ಗಳ ಅಂಶ, ಹೂಗಳ ಬಾಳಿಕೆ ಮೂಂತಾದ ಅಂಶಗಳಲ್ಲಿಯೂ ಕೂಡಾ ಇದೇ ಉಪಚಾರವು ಉತ್ತಮ ಫಲಿತಾಂಶ ಕೊಟ್ಟಿದ್ದು ಕಂಡುಬಂತು.