EFFECT OF BIOREGULATORS ON GROWTH, FLOWERING AND POSTHARVEST LIFE OF CROSSANDRA *(Crossandra infundibuliformis* (L.) Nees.*)*

By

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THESIS

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requirement for the degree of

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DECLARATION

I here by declare that the thesis entitled **"Effect of bioregulators on growth, flowering and postharvest life of crossandra (*Crossandra infundibuliformis* (L.) Nees.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship, associateship or other similar title, of any other university or society.

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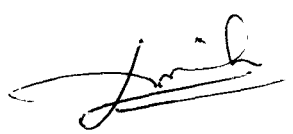
CERTIFICATE

Certified that the thesis entitled "**Effect of bioregulators on growth, flowering and postharvest life of crossandra (*Crossandra infundibuliformis* (L.) Nees.)**" is a record of the research work done independently by **Miss. C. Sreekala,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.



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C. Sreekala

To my parents

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ABBREVIATIONS

GA	- Gibberellic acid
BA	- N^6 Benzyl adenine
CCC	- Chlormequat (cycocel)
$ZnSO_4$	- Zinc sulphate
8-HQ	- 8-hydroxy quinoline
$CoCl_2$	- Cobalt chloride

Introduction

INTRODUCTION

Ornamental flowering plants are highly valued for the colour and beauty that they provide to the environment. Crossandra is one among such ornamental flowering plants, which is one of the important commerical flower crop of South India. It is cultivated on a commercial scale, mainly in Tamil Nadu and it finds a place in home gardens in Kerala. The flowers are priced for its attractive colour and long shelf life. In South India, the flowers are mainly used for hair adornment. Apart from India, it is also grown in Tropical Africa and Madagascar (Bailey, 1963).

Crossandra belongs to the family Acanthaceae. The genus *Crossandra* Salib. contains about 50 species (Wilkins, 1985), but only a few like *Crossandra infundibuliformis, C. guineensis, C. mucronata* and *C. subacaulis* are cultivated. *C. infundibuliformis* Syn, *C. undulaefolia*, the most commonly cultivated species, is a native of Southern India and Ceylon (Wilkins, 1985). Cutivars in this species include Orange, Delhi, Lutea yellow, Sebaculis Red etc. Earlier, the most important commercially cultivated variety was Orange (Raman *et al.*, 1969), but now, cv. Delhi, which is triploid (2n = 30) and produces more attractive flowers of bright deep orange colour is becoming very popular. Several breeding works such as hybridisation and mutation were done to improve the crop, mainly at TNAU.

In warm tropical areas of the world, it is perennial shrub, of 30-90 cm height. Leaves are about 5-12 cm long, glabrous , opposite and narrowly ovate to slightly lanceolate. Leaf margins are undulated and narrow at the petioles which are

about 1-2.5 cm long. Flowers are pubescent and overlap one another to form a dense, closely bracted, erect aechmea like, generally 15 cm long spikes with a peduncle of 2.5 cm. Individual flowers are composed of a corolla, which is a slender, tube about 2.5 cm long. The tube is flared and forms a 2.5-4 cm wide lip with 5 rounded lobes. The calyx is also five lobed and irregular and there are four stamens.

In cultivars which set seed, seed propagation is possible, but the viability of the seed is generally low and it detereorate on storage (Raman *et al.*, 1969). Cuttings rooted under mist are reliable planting materials, especially for cv. Delhi, where the seed set is meagre owing to its triploid nature.

Crossandra grows well in places where the temperature is around 30°C, and it cannot withstand low temperature and frost. It requires well drained soil rich in organic matter. Alkaline or saline soils are not suitable, because plants develop deficiency symptoms showing chlorosis.

Along with breeding, cultural and management practices are also very important in increasing productivity in crossandra. The use of bioregulaters has become an integral part of management practices in almost all floricultural crops, since they provide an easy way of increasing productivity. Bioregulators have the ability to induce early and profuce flowering, along with increased flower size and quality. Among them, there are chemicals, which provide dwarfing effect to plants and provide better postharvest qualities. Pulsing treatments and better storage environments help in increasing the shelf life of flowers. Therefore,the present study was undertaken with the following objectives

1. To find the effect of bioregulators on growth, flowering and floral characters in crossandra
2. To find the effect of bioregulators on the postharvest life of crossandra flowers and
3. To find the effect of pulsing and storage treatments on the postharvest life of cut spikes of crossandra.

Review of Literature

2. REVIEW OF LITERATURE

Crossandra is an important commercial flower crop of South India. Apart from crop improvement, application of bioregulators also help in achieving desirable traits in ornamental plants. Flower crops find extensive use of bioregulators in their developmental process. In fact, these have become an integral component of agro-technological procedures for some cultivated ornamental crops. They are having role from the germination of seed to senescence or ageing process. Large number of studies were conducted to know the effect of different bioregulators in many ornamental plants. This chapter attempts to review some of the literature regarding the effect of bioregulators in ornamental crops. Since research work on bio-regulators in crossandra is very meagre, related aspects in other ornamental flowering plants are also reviewed here. Literature collected is arranged under the following headings.

1. Effect on vegetative characters
2. Effect on flowering and floral characters
3. Effect on pigmentation
4. Effect on pulsing and storage
5. Effect on vase life

2.1 Effect on vegetative characters

In crossandra, Sayed and Muthuswamy (1974) conducted an experiment on the effect of growth regulators on growth and flowering, and reported that maleic hydrazide and TIBA suppressed stem elongation and increased branching, while GA elongated stems.

Adriansen (1976) reported that sprays of SADH reduced internodal elongation of crossandra plants, while ethephone was ineffective. Internodal elongation of plants could also be retarded by ancymidol in a recirculating nutrient solution (Adriansen, 1979). Khader *et al.* (1985) reported that foliar sprays of NPK fertilizers and farm yard manure with $ZnSO_4$ was found to increase the height, number of branches and yield per plant. $ZnSO_4$ was used at a concentration of 0.5%.

In *Chrysanthemum morifolium* B-Nine and cycocel each at 500 ppm and 10000 ppm and MH at 1000 ppm and 2000 ppm concentrations were tried by Sen and Naik (1973). Marked retardation in plant height over control was noticed under all the treatments, maximum suppression was with MH at 2000 ppm, followed by cycocel at 10000 ppm.

Shanmugan and Muthuswamy (1974) reported that, dwarfing effect of CCC was not observed in chrysanthemum varieties 'White' and 'Yellow' when concentrations of 5000 ppm, 10000 ppm and 15000 ppm were applied on them. Maharana and Pradhan (1977) reported that, number of leaves and lateral shoots in rose were better when applied with all the micronutrients such as Fe, Mn, B, Cu, Zn and Mn.

A retardation of growth by GA_3 100 ppm was reported in *Celosia cristata* by Nijis and Boesman (1981). CCC also retarded the stem growth when a concentration of upto 4000 ppm was applied.

Maharana and Pani (1982), based on their study on hybrid rose with GA (50-200 ppm), cycocel (2500-10000 ppm) or MH (250-1000 ppm) reported that GA and MH increased plant height where as cycocel at 5000 or 10000 ppm decreased it.

In *Jasminum grandiflorum* GA and IAA at 10, 100 or 1000 ppm increased shoot length, the most effective being IAA 10 ppm, which resulted in a 12.6% increase in shoot length compared with control (Bhattacharjee, 1983). Soil drench application of paclobutrazol gave effective control of plant height of potted chrysanthemums and foliar sprays were found to be not as effective as soil drench for controlling growth (McDaniel, 1983).

Foliar application of micronutrient containing commercial fertilizers with NPK, Mg, S, Cu, Mn, Fe, Zn and B was found to have very good result with respect to growth and flowering quality of chrysanthemum, when a 3% concentration was applied (Koriesh, 1984).

Richards and Wilkinson (1984) found that in camellia and rhododendron BA application was having no effect on branching when 100 mg/l was applied, while BA application promoted branching and growth in the miniature climbing rose cv. Jeanne la Joie. In *Calendula officinalis* L. cycocel and daminozide, applied at 250, 500, 1000 or 2000 ppm increased vegetative growth compared with controls (Abadalla *et al.*, 1986).

In *Chrysanthemum frutescens*, an increase in plant height, the number of shoots per plant, length of shoot and diameter of the plant was obtained with GA_3 application, especially at 500 and 1000 ppm concentration (Dahab *et al.*, 1987).

Application of GA_3 at 10, 20 or 40 ppm, 35 days after planting resulted in considerable increase in plant height.

Yamaguchi (1987) reported that, in carnation foliar spray with 100 ppm BA solution at several stages of primary branches, indicated by leaf age accelerated secondary branching at lower nodes.

In Anthurium, Imamura and Higaki (1988) reported that with increasing concentration of GA_3 (0 to 50 ppm), topped plants showed an increase in lateral shoots, while with increase in concentration of BA (0-1000 ppm) the number of lateral shoots increased in both topped and intact plants.

Application of paclobutrazol 200 to 2000 ppm four weeks after trans-planting in *Callistephus, Calendula* and *Portulaca*, resulted in significant reduction in plant height. In addition, peduncle length was also reduced in all the three species (Qrunfleh and Suwwan, 1988).

In Snapdragon cv. Ulan, increase in plant height was observed with 100, 200, 300, 400 or 500 mg per litre of GA, where as in another cultivar Irena there was no significant effect with any concentration applied (Rak and Nowak, 1989).

Qui and Liu (1989) reported that, in chrysanthemum paclobutrazol (1000 ppm) 1 to 7 times effectively inhibited growth and its effect varied with number of sprays. Treated plants were shorter with a green leaf colour. Experiments on *Jasminum grandiflorum* with Zn and Mg 0.5 and 0.25%, when four year old, showed that Mg or Zn sprays increased the number of shoots produced by 8.9 to 33.4 per cent compared with controls. Distilled water spray had no effect on shoot production (Bhattacharjee, 1990).

Lee and Lee (1990) reported that in cv. Parade of Gerbera, ancymidol and paclobutrazol when applied at rates of 0.25, 0.5 or 1.0 mg/pot as soil drench significantly reduced peduncle length, foliage height and width. Leaf area, total dry weight and fresh weight, were decreased whereas leaf thickness was markedly increased. Among the two,paclobutrazol was more effective, and compact pot plants could be produced by single drench application of paclobutrazol at 0.25 to 0.5 mg per pot.

GA_3 (0-100 ppm) applied at 60 and 75 days after sowing in carnation, showed that, GA_3 application promoted linear growth as well as lateral branching, especially at 50 ppm concentration (Mukhopadhyay, 1990). Seume (1990) reported that compact pot plants were produced in pot carnations when treated with chlormequat.

In eight year old *Jasminum sambac*, GA_3 sprayed at 100 and 200 ppm, 15 days after pruning resulted in increased primary shoot length and reduced number of laterals (Gowda and Gowda, 1991).

Lalimer (1991) reported that in seedlings of *Zinnia elegans* (cv. Peter Pan Scarlet) spraying 5000 ppm daminozide, 200 ppm ancymidol or 40 and 90 ppm paclobutrazol reduced leaf expansion and stem elongation before transplanting. In potted *Salvia splendens*, treatment with paclobutrazol, daminozide and chlormequat inhibited internode elongation and decreased leaf area. Treatments also increased the ratio of the number of nodes with leaves to total number of leaves. Higher paclobutrazol concentrations (80 or 160 ppm) caused leaf crinkling (Mao *et al.*, 1991).

Singh *et al.* (1991) reported that in African Marigold higher GA_3 concentrations increased growth and flower weight, when five different concentrations (100-500 ppm) were applied 22 days after transplanting. Shedeed *et al.* (1991) reported that in china aster plant height was increased (by approximately 5-6 cm) along with an increase in the fresh and dry weight compared with unsprayed controls. Also, kinetin treatments generally reduced plant height compared with controls and shortest plants were obtained with 10 ppm kinetin + 10 ppm IAA.

In chrysanthemum, Gilbertz (1992) reported that earlier the application of growth retardants as paclobutrazol or uniconazole, shorter the plant stature. Hashim (1992) made growth control studies in oleander, plants were sprayed 3 times at 3 months intervals with 50-200 ppm alar (daminozide), 250-1000 ppm paclobutrazol or distilled water (control). Result indicated that paclobutrazol was more effective growth retardant than daminozide, and plant height was decreased as paclobutrazol concentrations increased.

In Marigold, experiment with different growth regulators showed that, plant height was minimum with 8000 ppm CCC, which also account for maximum stem girth. Number of lateral shoots per plant was significantly increased by application of MH and CCC. Primary laterals were maximum with 4000 ppm CCC (Singh and Rathore, 1992).

Aswath *et al.* (1994) tried plant growth retardants, alar, cycocel, MH and TIBA, at three different levels in china aster. Higher number of leaves and branches were obtained with 1500 ppm cycocel, while MH 1500 ppm caused a reduction in plant height.

In growth regulator studies on rose cv. Super Star Goyal and Gupta (1994) tried GA (15, 30, 45 ppm), BA (25, 50, 75 ppm) and CCC (250, 500, 750 ppm) thrice, viz., one month after pruning, 20 days and 40 days after the first application. Study showed that shoot length and flower diameter were maximum with GA 45 ppm and minimum with BA 75 ppm.

Saldana (1994) reported that, with the foliar spray treatments, plant height decreased with increasing paclobutrazol concentration in potted chrysanthemum. In pot plants best result was obtained with a single spray of 100 ppm paclobutrazol one month after potting.

In an experiment with chrysanthemum, Talukdar and Paswan (1994) reported that GA_3 20 ppm resulted in tallest plants which had 31.3 cm height compared with 19.8 cm for controls. While spraying with CCC 5000, 10000 or 15000 ppm, 35 days after planting resulted in shorter plants, with 16.8 cm height compared to 19.8 cm in control.

2.2 Effect on flowering and floral characters

Sayed and Muthuswamy (1974) conducted growth regulator studies in crossandra, and reported that, the number of flowers was increased by MH, phosphon and TIBA, while GA delayed flowering.

The effect of micronutrients on growth and yield performance of crossandra was investigated by Khader *et al.* (1985) and they found that NPK + farm yard manure + $ZnSO_4$ 0.5% was superior, which increased the yield per plant. This treatment increased the number of flowers per spike and length of spike, which contributed to yield increase.

Shanmugan *et al.* (1973) studied the effect of GA_3, MH, cycocel and TIBA on potted chrysanthemum plants. GA_3 induced early flowering where as MH delayed flowering. Flower yields were reduced by the treatment of MH (1000, 2000 ppm) and cycocel (5000, 15000 ppm) and TIBA (100, 200, 2000 ppm) in 'Yellow' as well as 'White' cultivars.

Shanmugan and Muthuswamy (1974) studied the effect of cycocel and TIBA on chrysanthemum. Cycocel was sprayed at 5000, 10000 and 15000 ppm and TIBA at 100, 200 and 400 ppm, thrice between 30 and 60 days from flowering. Cycocel at 15000 ppm and all TIBA treatments increased flower size in the cultivar 'White' but lessened it in 'Yellow' cultivar. All treatments hastened flowering in 'Yellow'. Except 400 ppm TIBA, all treatments reduced flower yield in both cultivars.

Study on the effect of growth regulators on growth and flowering of Edward rose by Nanjan and Muthuswamy (1975) showed that number of flowers were increased with 200 ppm GA treatment.

Pappian and Muthuswamy (1977) applied five growth regulators to 3 year old plants of *Jasminum grandiflorum* bimonthly intervals starting 45 days after pruning and found that cycocel treatment significantly increased the number of flowers and induced early flowering. Cycocel treated plants also flowered for longer period.

GA applied at 250 ppm was found to advance flowering by 4-5 days and greatly increased the number of flowers/plant, and augmented flower length and fresh weight in carnation (El-Shafie *et al.*, 1981).

Based on his studies in *Jasminum grandiflorum*, Bhattacharjee (1983) reported that all the cycocel treatments, B-9 at 1000 ppm and NAA at 10 ppm induced early flower initiation. Corolla tube length was reduced by all treatments.

Reddy and Sulladmath (1983) reported that GA at 100 to 300 ppm advanced flowering in china aster, and increased the duration of flowering. Duration was longest in plants treated with GA at 300 ppm (24 to 30 days) compared to control (19 to 23 days).

Papadimitrion and Manios (1984) studied the effect of GA_3 on outdoor 'White Sim' carnation production and reported that, GA_3 had no effect on number of flowers produced, but high rates (120 to 240 ppm) significantly increased flower length and fresh weight.

In miniature climbing rose cv. Jeanne la Joie, BA treatment produced double the number of terminal inflorescences in addition to good branching (Richards and Wilkinson, 1984). In gerbera, Guda *et al.* (1985) reported that in cv. Cocktail and Petre, treatment with GA_3 100 ppm + 0.2% dimethyl sulphonide + 0.2% Tween 20), resulted in 133% more flowers than control at 20 days after treatment, but the difference was less at 40 days.

Application of GA_3 at 200 ppm concentration was reported to produce greatest number of flowers in marigold (Lal and Mishra, 1986). Flower size was greatest at 150 ppm GA_3.

Dahab *et al.* (1987) studied the effect of GA_3 at either 250, 500 or 1000 ppm, three times through out the early stages of growth in *Chrysanthemum*

frutescens. GA_3 accelerated flowering and decreased the number of inflorescence per plant. The fresh weight of the flowers were also decreased by GA_3.

A trial in *Jasminum multiflorum* by Murali and Gowda (1988) showed that, 500 ppm chlormequat gave best results with regard to days to flowering, duration of flowering and mean flower yield. Days to flowering was reduced to 34.5 from 56.5 days, duration of flowering increased to 275.5 days compared with 221.5 days and mean flower yield increased to 1118.29 g/bush from 395.47 g/bush.

Experiment with Bonzi (paclobutrazol) applied at 2.5, 5.0 or 10 ml/litre and chlormequat 2.0 g/litre in cv. Blanche of chrysanthemum showed that both paclobutrazol and chlormequat increased flower diameter (Ripka and Szanto, 1988).

In *Chrysanthemum morifolium*, GA induced early flowering, while cycocel treatment resulted in sturdy and thick flowering stems. GA_3 was applied as spray at 100 ppm, 2 times and CCC as spray or soil drench at 5000 ppm. It was also found that fresh weight and dry weight of inflorescence stems were increased by GA_3 while cycocel gave the highest inflorescence fresh weight (Koriesh *et al.*, 1989).

Foliar sprays containing 1000 or 2000 ppm cycocel (chlormequat) or maliec hydrazide were applied before pruning and 15 days after in *Jasminum sambac*. Treated bushes flowered earlier, longer and more profusely than untreated ones. Cycocel was more effective than MH and for both 1000 ppm was more effective than 2000 ppm, with which the number of flowers per bush was increased to 4645.3 from 2296.5 and their total weight to 1212.5 g from 549.9 g. Peak flowering was observed during April-June (Gowda and Gowda, 1990a).

Lee and Lee (1990) reported that, in gerbera paclobutrazol and ancymidol significantly reduced peduncle length and had no effect on the number of days to flowering. Paclobutrazol was more effective than ancymidol. Increased flower yield in marigold with CCC and MH was reported by Gowda and Jayanthi (1991). They found that spraying cycocel at 2000 ppm twice at second and fourth week after transplanting gave quality and higher flower yields.

In *Salvia splendens* spraying was done with 40, 80 or 160 ppm concentration paclobutrazol, 0.25, 0.5 or 1.0 per cent daminozide or 0.8 or 1.6 per cent chlormequat. Flower number was increased by all treatments. Even higher paclobutrazol concentrations (80 or 160 ppm) did not affect the number of days to flowering, though it caused a shortening of flower spikes. Application of 1.6 per cent chlormequat or 0.5 or 1.0 per cent daminozide delayed flowering by 1 to 2 weeks (Mao *et al.*, 1991).

Grzesik *et al.* (1992) studied the effect of GA_3, paclobutrazol and nutritional levels in rhododendron. One application of 250 mg/litre paclobutrazol retarded growth. More flower buds were produced by plants treated with paclobutrazol and GA_3 and they at times flowered better than untreated plants or plants treated with either chemical alone. They also reported that plants treated with growth regulators used more macro elements than untreated one.

In marigold, Singh and Rathore (1992) reported that, maximum number of flowers per plant were observed with CCC 4000 ppm.

Datta *et al.* (1993) reported that in *Chrysanthemum indicum* cv. Co-1, GA_3 application resulted in earlier flowering and the concentrations tried were GA_3

(50, 100 or 150 ppm), NAA (50, 75 or 100 ppm), MH (250, 500 or 1000 ppm) or CCC (2000, 3000 or 4000 ppm) delayed flowering compared to control. All growth regulator treatments significantly increased the duration of flowering, which was the longest in GA_3 50 ppm treatment. Flower quality, viz., size and stalk length and yield were improved by most treatments and GA_3 150 ppm gave the highest flower yields.

In eight cultivars of chrysanthemum, foliar application of 100 ppm GA_3, increased the weight and diameter of flowers (Dehale *et al.*, 1993).

In china aster, Aswath *et al.* (1994) studied the effect of alar, cycocel, MH and TIBA and reported that, flower bud appearance was delayed by 12.4, 7.54 and 3.54 days with spraying MH, cycocel and alar at 1500 ppm respectively as compared to control. Alar and cycocel (1500 ppm) resulted in increased number of flowers and the flower diameter was reduced by growth retardant application.

Farooqi *et al.* (1994) reported an increase in the number of flowers in *Rosa damascena* with 10 mg/l kinetin. Mertens (1994) reported that, bud formation in rhododendrons were stimulated by the application of paclobutrazol (200 mg/litre). It was also found that, double application produce more flowers.

2.3 Effect on pigmentation

Growth substance mediated chlorophyll changes in *Tagetes erecta* L. was studied by Vidhu and Murthy (1985). Three sprays with IAA (50 to 500 ppm), TIBA (50 to 500 ppm), GA_3 (50 to 500 ppm) or kinetin (10 to 100 ppm) were given. The result showed that increased IAA concentrations, low GA_3 and TIBA concentrations and all kinetin concentrations stimulated chlorophyll synthesis.

Nagarajaiah and Reddy (1986) based on their study on 'Queen Elizabeth' cut roses reported that GA (50 to 400 ppm) reduced the leaf chlorophyll content. In azaleas Bonzi (paclobutrazol) 20, 25 or 30 ml/litre produced darker green leaves, but had no effect on flower colour (Henrsel, 1986).

Effect of gibberellic acid on growth, flowering and constituents of *Chrysanthemum frutescens* was studied by Dahab *et al.* (1987) and reported that the chlorophyll and carotenoids increased by GA_3 application. GA_3 was sprayed three times through out the early growth stages with 250, 500 and 1000 ppm concentration. B-9 (daminozide) at 1500 to 6000 ppm and CCC was found to increase the leaf thickness, amount of palisade tissue, leaf weight and chlorophyll content in petunia (Shi and Li, 1989).

Starman and Kelly (1989) reported that in sunflower ancymidol (66 to 132 mg/litre ai) resulted in darker green leaves and increased the chlorophyll content per unit leaf area compared with controls. However, chlorophyll 'a', 'b' and total chlorophyll were increased in only two cultivars when measured on a weight basis using high performance liquid chromatography. Ancymidol increased the three xanthophyll levels (neoxanthin, violaxanthin and lutein) in the four cultivars, but had no effect on ß-carotene when measured on weight basis. Also the dwarf cultivar had a significantly higher level of ß-carotene than the other three.

Studies on snapdragon by Rak and Nowak (1989) with 100, 200, 300, 400 or 500 mg/litre GA showed that GA application had no effect on flower colour or shape.

Paclobutrazol at 250 to 2000 ppm and daminozide at 1500 to 5000 ppm, 1 to 7 times causes a green leaf colour in chrysanthemum (Qui and Liu, 1989).

In *Jasminum sambac*, Gowda and Gowda (1990b)reported that MH and cycocel at 1000 ppm was more effective than 2000 ppm in increasing the chlorophyll a content. Contents of chlorophyll b and total chlorophyll were increased most by 2000 ppm MH after pruning.

Studies with ancymidol and paclobutrazol applied at rates of 0.25, 0.5 or 1.0 mg/pot as soil drench in gerbera, showed that both the retardants markedly increased the leaf thickness and chlorophyll content (Lee and Lee, 1990).

In potted salvia, paclobutrazol (40, 80 or 160 ppm), daminozide (0.25, 0.5 or 1.0 per cent) or chloromequat (0.8 or 1.6 per cent), sprayed once or twice increased the leaf chlorophyll content (Mao *et al.*, 1991).

In poinsettia, paclobutrazol applied as spray or soil drench had no effect on bract colour (Torres and Saldana, 1992). Goyal and Gupta (1994) based on their studies on rose cv. 'Super Star' with GA (15, 30, 45 ppm), BA (25, 50 and 75 ppm) and CCC (250, 500 and 750 ppm) reported that maximum anthocyanin content was recorded with CCC 750 ppm.

2.4 Effect on pulsing and storage

Mukhopadhyay *et al.* (1980) studied the effect of chemicals on the postharvest behaviour of crossandra. Freshly opened flowers were harvested in the morning and soaked for 2 hours in solutions of different chemicals. It was found that about 50 per cent of the flowers remained fresh for upto 120 hours after treatment

with boric acid (0.5 to 2.0 per cent), aluminium sulphate (0.1 per cent) or silver nitrate (0.001 to 0.05 per cent), compared with 96 hours in the control.

Halevy and Mayak (1974) reported that, the flowers should be precooled before packing and storing, since the cooling of the flowers in closed boxes was very slow.

Ethylene scrubbers in shipping boxes have been suggested, and some commercial preparations containing brominated activated charcoal and/or $KMnO_4$ are available. It was shown, however, that ethylene scrubbers were effective only when used in large quantities, which render the use of ethylene scrubbers impractical (Akamine, 1976).

Mayak and Kofranek (1976) suggested that pulsing reduces the sensitivity of flowers to ethylene.

Effect of cold storage and preservative solutions on cut carnations were studied by Accati and Sulis (1977) and found that even the most tightly closed buds opened normally in a suitable solution after cold storage for three weeks. The best solution contained 200 ppm hydroxy quinoline sulphate, 50 ppm aluminium sulphate, 25 ppm silver nitrate and 10% sucrose.

Halevy *et al.* (1978) reported that precooling was very effective in maintaining the temperature at a lower level when properly packed. Based on their experiment on carnations, chrysanthemums and roses, they reported that pre-shipment pulsing of carnations and rose with 10% sucrose + 150 ppm citric acid solution for 16 hours increased longevity and flower diameter.

Report by Laurie *et al.* (1979) said that flowers in bunches are placed in carton with stem and head ends alternating and paper rolls or pillows are used to support and cushion the flowers. Wax or tissue paper kept around the flowers also serve protection. Packing material must not absorb water from the flowers. They also reported that refrigerated or iced facilities should be used in warm weather and insulated or heated ones in cold weather to keep up with temperature extremities.

Studies on pre-treatment and storage of china aster by Kofranek *et al.* (1979) showed that pretreatment of stems with $AgNO_3$ or physan 20 resulted in two or three fold increase in the flower life, compared with that of controls. Also adding sugar to $AgNO_3$ and citric acid solution was beneficial particularly for flowers stored in a carton for 4 days at 35 or 45°C.

Halevy and Mayak (1981) reported that in several, simulated and actual long term (5 to 28 days) experimental shipment of flowers by land or sea, flower quality was comparable and in some cases better than that of uncontrolled, air-shipped flowers for much shorter period by combining pulsing, precooling and transport under refrigeration.

Pre-treatment with chemicals for 20 hours and the effect on dry storage (in sealed polythene bags at 1 or 4°C upto 28 days) and wet storage (held at 4°C for 28 days in water) was studied by Goszynska *et al.* (1985) on carnation. The results showed that pretreatment with 200 mg/litre 8 HQC + 50 mg/litre $AgNO_3$ + 10% sucrose and dry storage gave the longest vase life after storage.

Randhawa and Mukhopadhyay (1986) reported that common method of packing as in bamboo baskets and gunny bags resulted in low storage life. Most suitable package material for cut blooms was hardboard boxes, which were not only cheap cost wise, but also light in weight and easy to handle.

Sucrose (5 to 25%) and 200 mg/litre 8 HQ pre-treatment promoted flower opening in freesia. Twenty four to 48 hour pulse treatment with sucrose resulted in complete inflorescence development and prolonged the vase life. Reduced sucrose concentrations and increased pulse duration were not as effective (Woodson, 1987).

Rosa hybrida stems harvested at closed bud stage were re-cut and placed in 200 mg 8 HQS/litre + 20, 40, 60, 80 or 100 mg sucrose/litre for 6 hours at 20°C, after which they were placed in open polythene bags at 2°C for 1 hour and then sealed and kept for 3, 6 or 9 days. Stems pulsed with 60, 80 or 100 mg sucrose/litre and kept at 20°C for 3 days had the longer vase life and greater flower diameter than controls (Deambrogio and Garibaldi, 1991).

Corrugated fibre board cartons were reported as good packing material for flowers (Bhattacharjee, 1994). Also, ethylene scrubbers containing $KMnO_4$ might be added to the pack containing orchids which are highly sensitive to ethylene. He also reported that precooling is essential for removing field heat from the harvested material, by which temperature is brought down to about 1°C from 20°C to 30°C in the field.

2.5 Effect on vase life

In a study with carnation, Halevy and Kofranek (1977) reported that stem base treatment with $AgNO_3$ 1000 ppm for 10 minutes was effective in delaying senescence to a lesser extent.

Cho and Lee (1979) reported that, in cut rose cv. Mary De Vor, 3 to 5 per cent sucrose and 300 ppm $Al_2(SO_4)_3$ extended the vase life from 6 to 9 days, and there was a positive correlation between fresh weight increase and longevity. In cut carnations the most effective treatment was a combination of 3 per cent sucrose + 50 ppm silver nitrate, which more than doubled the vase life compared with that of flowers in tap water.

Studies on cut roses and carnations by Mahr and Hanan (1980) revealed that cobalt nitrate (Co) at 270 or 360 ppm and 8-hydroxy quinoline citrate (8-HQC) increased the vase life of rose cv. Samantha from 7.2 days in deionized water to 11.5, 11.7 and 13.2 days respectively. In many rose cultivars 200 ppm 8 HQC + 360 ppm Co was more effective than either preservative alone and in white carnations longest vase life (10.2 days) were obtained in 8-HQC at 150 ppm + silver thiosulphate at 150 ppm.

In carnation maximum vase life and quality were achieved with a solution of 8-HQC at 200 ppm and 2% sucrose (Choi and Roh, 1980). Lee *et al.* (1980) reported that, the longevity of cut carnation can be significantly increased to 12.4 to 13.6 days from 5.6 days in the control, when treated with sucrose + $AgNO_3$ + HQ solutions. Flower diameter was also significantly greater in these treatments (54.61 mm compared with 44 mm in controls).

Co^{2+} 1.5 mM gave the best result on increasing vase life of cut flowers of rose cv. Samantha (Venkatarayappa *et al.*, 1980).

Ferreira and Swardt (1980) reported that of the several cut flower preservative solutions listed for the rose cv. Sonia, the best results were obtained with silver nitrate (2.5 mg/dm^3) + 8 HQC (130 mg/dm^3) + citric acid (200 mg/dm^3) + sucrose (30 g/dm^3), which extended the vase life from 7 days in the deionised water to 17 days.

Vase life of carnations was increased from 4 or 5 days to upto 10 days when 6 to 8 per cent sucrose was used (Amariutei and Burzo, 1981). Venkatarayappa *et al.* (1981) reported that vase life was extended when sucrose and Co^{2+} 1.5 mM were given to holding solutions.

In zinnia Stemart and Brown (1982) reported that flowers lasted long in solutions of 200 mg/litre of 8-HQC and 1% sucrose.

In trials with GA_3 and CCC, sprayed 45 and 75 days after planting in snapdragon showed, that the vase life was longest (15 to 22 days compared with 13 to 17 days in the control) with GA_3 at 50 to 200 ppm (Sarhan and El-Sayed, 1983).

Chung *et al.* (1986) reported that, in cut carnation cv. Scania, the solution containing sucrose 5% + $AgNO_3$ increased vase life 2 to 4 times than with distilled water controls. Sucrose 5 per cent + silver thiosulphate (0.3 mM) solution extended vase life to about 1.8 times.

Fully opened flowers of china aster, recorded maximum vase life (8 and 8.7 days) when placed in solutions containing 0.2 per cent $Al_2 (SO_4)_3$, followed by those containing 2 per cent sucrose (Mantur and Nalawadi, 1989).

Reddy (1988) based on trials with cut roses reported that, 0.5, 1.0, 1.5, or 2.0 mM cobalt chloride nitrate or sulphate inhibited vascular blockage in stems of the cv. Samantha and maintained a high water flow rate through the stems, leading to significantly increased water uptake by cut flowers. Co partially closed stomata and hence reduced the water loss, water uptake ratio and maintained a high water potential in the cut flowers. As a result, high fresh weight of flowers was maintained resulting in increased vase life.

In experiment with cut 'Queen Elizabeth' roses Nagarajaiah *et al.* (1989) reported that, cobalt sulphate or sucrose used individually extended the vase life by upto 4 days compared to 3.3 days in control, whereas when used in combination the vase life was 7 days. The best combination was 0.5 mM cobalt sulphate + 4 per cent sucrose.

Rath *et al.* (1991) reported that in *Rosa hybrida* vase life was increased when cut stems of flowers were placed in sucrose solution, than in deionised water. Among the silver nitrate and potassium aluminium sulphate, the latter was found to have higher vase life extending capacity when used in combination with sucrose.

Based on their study on Rose cv. Super Star with foliar spray of GA (15, 30, 45 ppm), BA (25, 50, 75 ppm) and CCC (250, 500, 750 ppm) thrice viz., one month after pruning, 20 days and 40 days after first application, Goyal and Gupta (1994) reported that the vase life of rose flowers was enhanced by GA and CCC whereas it decreased with BA. The maximum vase life was recorded with GA 45 ppm and minimum was observed with BA 75 ppm.

Materials and Methods

3. MATERIALS AND METHODS

Investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala, from June 1996 to June 1997. Triploid crossandra cultivar 'Delhi', which produces attractive bright deep orange flowers was used in the present study. Owing to triploidy seed set was very meagre in this cultivar, so rooted cuttings were used as the planting material. Bioregulators have the capability to increase the spreading and branching characters of the plant. So large number of propagules can be made available. Role of bioregulators in increasing the productivity can also be not ruled out. Hence the study was taken up to find out the effect of different bioregulators on the growth, flowering and postharvest life of crossandra [*Crossandra infundibuliformis* (L.) Nees.]. Packing of the flowers as usually done in bamboo basket or gunny bags result in low storage life (Randhawa and Mukhopadhyay, 1986). So studies were done to prolong the postharvest life of flowers with different pulsing treatments and proper storage conditions. Thus two experiments were conducted with the objective of finding

(1) The effect of different bioregulators on growth and floral characters of crossandra,

(2) Effect of bioregulators on postharvest qualities of crossandra flowers, and

(3) Effect of different pulsing treatments and storage conditions on the postharvest life of cut spikes of crossandra.

3.1 Experiment I

Effect of bioregulators on growth, flowering and floral characters of crossandra.

3.1.1 Variety and planting material used for the study

Mist propagated rooted cuttings of triploid crossandra cultivar 'Delhi' which were cared against diseases and pests were used as planting material. The spikes and flowers obtained from these plants were used for the subsequent studies.

3.1.2 Design of the experiment

The experimental design was RBD with 22 treatments (20 bioregulator treatments and two controls) and two replications.

3.1.3 Layout and planting

Land was prepared by weeding, followed by thorough digging. Raised beds were made with the size of 2.1 x 2.7 m. On these beds farm yard manure at the rate of 5 kg/bed was applied and incorporated well. After a fortnight, planting pits were made at a spacing of 60 x 45 cm and rooted cuttings were planted during the end of June, 1996. Planting was done in such a way to give 16 plant per plot, comprising of 4 plants in each row, on either way. Cuttings established well within two weeks.

3.1.4 Treatments

First spraying of bioregulators was done one month after planting and

subsequent sprayings were given at bimonthly intervals. A spray volume of half litre was used for each bed comprising of 16 plants. Bioregulators used and their concentrations were as follows:

T_1 - GA 100 ppm

T_2 - GA 100 ppm + 1% urea

T_3 - GA 200 ppm

T_4 - GA 200 ppm + 1% urea

T_5 - BA 100 ppm

T_6 - BA 100 ppm + 1% urea

T_7 - BA 200 ppm

T_8 - BA 200 ppm + 1% urea

T_9 - Paclobutrazol 500 ppm

T_{10} - Paclobutrazol 500 ppm + 1% urea

T_{11} - Paclobutrazol 1000 ppm applied for the first application which was changed to 250 ppm from second application onwards

T_{12} - Paclobutrazol 1000 ppm + 1% urea applied for the first application which was changed to paclobutrazol 250 ppm + 1% urea from second application onwards

T_{13} - CCC 500 ppm

T_{14} - CCC 500 ppm + 1% urea

T_{15} - CCC 1000 ppm

T_{16} - CCC 1000 ppm + 1% urea

T_{17} - $ZnSO_4$ 0.25%

T_{18} - $ZnSO_4$ 0.25% + 1% urea

T_{19} - $ZnSO_4$ 0.5%

T_{20} - $ZnSO_4$ 0.5% + 1% urea

$T_0(1)$ - Control (water spray)

$T_0(2)$ - Control (no spray)

3.1.5 Cultural and management practices

Partial shading and irrigation were given during sunny days immediately after planting. In addition to the basel application of FYM, application of fertilizers as urea, factomphos and MOP were done so as to have 15.3 kg N_2, 10.51 kg P_2O_5 and 24.4 kg K_2O per hectare during each application. Fertilizer applications were done two months and eight months after planting and at each time earthing up was done after fertilizer application. Due to severe weed growth, weeding was done at monthly intervals or even fortnightly intervals. Daily irrigation was done during summer months. Cutting and removal of dried up spikes were done regularly.

Diseases such as leaf spot and rotting of basal part of the stem were noticed during early stages of plant growth and was recovered with foliar spray and drenching of Indofil M-45 at 0.3% concentration respectively. Among the pests, *Helicoverpa* was seen, feeding on early stages of spike during the months of August to January and June. Mechanical removal by hand picking was done.

3.1.6 Observations recorded

In each plot, four plants at the centre of the plot were selected as observational plants and the following observations were taken, at monthly intervals.

3.1.6.1 Vegetative characters

3.1.6.1.1 Height of the plant

Height of the plant from the ground level upto the top of the upper most leaf were taken in centimetres.

3.1.6.1.2 Plant spread

Spread of the plant was recorded on north-south and east-west directions and these two were multiplied to get the spread in square centimeters.

3.1.6.1.3 Number of leaves produced

From each observational plant, total number of leaves were counted.

3.1.6.1.4 Leaf characters

Third pair of leaves from the top of the plant were selected for recording leaf characters.

3.1.6.1.5 Leaf length

Length of the leaf from the tip to the base of the petiole were recorded in centimetres.

3.1.6.1.6 Leaf width

Width at the middle portion of the leaves were measured in centimetres.

3.1.6.1.7 Leaf area

Single leaf area were calculated from length and width of the leaf using an equation, A = K (L x B) where A is the leaf area, K, leaf area constant (0.553), L, length and B, width of the leaf (Swaminathan *et al.*, 1994). This single plant leaf area was multiplied with the total number of leaves to get the whole plant leaf area approximately, in square centimetres.

3.1.6.1.8 Number of branches

Counted the total number of branches remaining on the plant including the main branches and axillary branches.

3.1.6.1.9 Pest/disease incidence

Noted the occurrence of any pest or disease through out the study period.

3.1.6.2 Floral characters

3.1.6.2.1 Time taken for the first spike emergence

Time required for the emergence of first spike after the spray was recorded in days.

3.1.6.2.2 Time taken for the first floret appearance on the spike

Time from the emergence of the spike to the appearance of the lower most floret was noticed in days.

3.1.6.2.3 Time required for the opening of a floret

Time required from the appearance to the opening of a floret was noted in days.

3.1.6.2.4 Time required for complete opening of florets in a spike

Time from first floret opening to the opening of the last floret in a spike was recorded in days.

3.1.6.2.5 Number of florets in a spike

Total number of florets that were produced on each spike were counted.

3.1.6.2.6 Number of spikes per plant

Total number of spikes on each plant, including those in all stages of development were counted at the time of observation and recorded as the number of spikes per plant in a month.

3.1.6.2.7 Number of florets per plant

Total number of florets produced on each plant were recorded by multiplying the number of spikes which started opening with the number of florets in a spike.

3.1.6.2.8 Number of spikes produced in a month

Total number of spikes emerging in every month of the study was recorded.

3.1.6.2.9 Length of a floret

Length of each floret from the tip of the floret to the base was measured in centimetres.

3.1.6.2.10 Diameter of a floret

Diameter of the floret was taken in two directions (i) across the length of the floret and (ii) along the length of the floret and the average was taken in centimetres as the diameter of the floret.

3.1.6.2.11 Length of a spike

Spikes on which the emergence of the floret had completed were taken and the length from the tip of the last pair of florets to the base of the stalk were recorded in centimetres.

3.1.6.2.12 Diameter of a spike

Since the spikes showed a rectangular surface, the circumference was measured in centimetres and recorded as the diameter of the spike.

3.1.6.2.13 Longevity of a floret in an intact spike

Total number of days a floret retained on the spike was taken by noting the day of opening of the floret and the day on which it falls off.

3.1.6.2.14 Longevity of a spike in the field

Time taken from the emergence of the spike, till the last floret on it falls off was noted to record the longevity of a spike in the field.

3.1.6.2.15 Stalk length of the spike

Length of the stalk of the spike of each treatment was measured in centimetres.

3.1.6.3 Pigmentation

3.1.6.3.1 Chlorophyll content of the leaves

Chlorophyll content of leaves were estimated by spectrophotometry. Acetone extract of the third pair of leaves were taken and the absorbance at 645 nm and 663 nm were measured (A.O.A.C., 1960).

3.1.6.3.2 Total carotene content of flowers

Carotene content of flowers were also estimated using spectrophotometry. Acetone extract were taken from blended mass in water, and read the absorbance at 663 nm, 645 nm and 490 nm and the total carotene content was calculated (Jayaraman, 1981).

3.2 Experiment II. Postharvest life of the cut spike

Spikes from all the treated and untreated plants were subjected to various pulsing/precooling and storage treatments to know the postharvest behaviour of the spike. They were also subjected to treatment with different holding solutions to know its effect on vase life.

3.2.1 Design of the experiment

Design of the experiment was factorial RBD with two replications.

3.2.2 Pulsing and storage

3.2.2.1 Treatments

3.2.2.1.1 Stage of spike

Spikes were harvested when the basal florets start opening to study the postharvest behaviour of spike. But they failed to open successfully and showed a faint colour. So spikes at different stages were cut and kept in tap water. The stages were

1. First pair of floret start opening
2. 2-4 florets opened
3. 4-6 florets opened
4. 6-8 florets opened
5. Later stages of development.

3.2.2.1.2 Pulsing and precooling

Stages which were most suitable to be used as cut flowers were harvested later and subjected to the following preliminary pulsing treatments for 24 hours and stored in corrugated carton with paper bits. Preliminary pulsing treatments were

Sucrose - 5%, 10%

8-HQ - 250 ppm, 500 ppm

$CoCl_2$ - 100 ppm, 200 ppm

$AgNO_3$ - 0.05%, 0.1%, 0.5%, 1%

Based on the result of the preliminary studies the following levels and combinations of the chemicals were selected for pulsing treatments.

P_0 - control (treated with distilled water)

P_1 - sucrose 10% + 8-HQ 500 ppm

P_2 - sucrose 10% + $CoCl_2$ 200 ppm

P_3 - sucrose 10% + 8-HQ 500 ppm + $AgNO_3$ 0.05%

P_4 - sucrose 15% + $CoCl_2$ 200 ppm

P_5 - sucrose 15% + 8-HQ 500 ppm

Pulsing treatments were given both for 12 hours and 24 hours. Precooling treatments were tried for 12 hours and 24 hours and among them, the better one was selected.

Spikes from all the field treatments were harvested, and subjected to all of the above pulsing and precooling treatments, and were stored in different containers.

3.2.2.1.3 Storage

To standardise the concentration and method of application of $KMnO_4$ in storage containers few methods were tried. The treatments were

$KMnO_4$ kept in corrugated carton	-	1 g/100 g flowers 2 g/100 g flowers
$KMnO_4$ wrapped in muslin cloth and kept inside corrugated carton	-	1 g/100 g flowers 2 g/100 g flowers
$KMnO_4$ solution kept inside corrugated carton	-	0.5% solution 1.0% solution

$KMnO_4$ solution was prepared and newspapers impregnated with this solution were dried and used for lining corrugated carton. $KMnO_4$ concentrations in the solutions were 0.25 per cent and 0.5 per cent.

Spikes which received pulsing treatments were kept in each of the above conditions, and based on the storage life of the spike in each case, the last two were selected for further studies.

Spikes from all the field treatments, which received each pulsing treatments were kept in the following storage containers.

S_0 - Bamboo basket

S_1 - Bamboo basket + activated charcoal

S_2 - corrugated carton with paper bits.

S_3 - perforated card board box with wet newsprint

S_4 - corrugated carton with lining of newsprint dipped in 0.25% $KMnO_4$ solution and dried thereafter

S_5 - corrugated carton with lining of newsprint dipped in 0.5% $KMnO_4$ solution and dried thereafter

S_6 - Polythene bag 100 guage
S_7 - Polythene bag 200 guage
S_8 - Polythene bag 300 guage

} under refrigerated condition

3.2.2.2 Observations recorded

3.2.2.2.1 Postharvest storage life of the spike

Life of the spike after each pulsing and storages and precooling and storage treatments were recorded in hours.

3.2.2.2.2 Fresh weight of the spike

Weight of each spike immediately after harvest were noted in grams.

3.2.2.2.3 Rate of solution absorption

The amount of solution absorbed by each spike was found out in millilitres by noting the volume of the pulsing solution before and after pulsing.

3.2.2.2.4 Postharvest loss in weight

Weighed each spike after the completion of postharvest life and this was substracted from the fresh weight, to get the postharvest loss in weight in grams.

3.2.2.2.5 Time required for complete opening of florets in a spike

Time from the day on which the spike was kept in water after storage, till the last floret that opened in it was noted in days.

3.2.2.2.6 Number of florets opened at a time

The number of florets that could open at a time during the postharvest period was recorded.

3.2.3 Vase life

Spikes of the most suitable stage for cut flowers from all the bioregulator treatments were kept in holding solutions of different combinations to find the vase life of cut spikes.

3.2.3.1 Treatments

Treatments included in studying the vase life of cut spikes were as follows.

V_0 - control (distilled water)

V_1 - sucrose 3% + 8-HQ 200 ppm

V_2 - sucrose 3% + 8-HQ 200 ppm + $AgNO_3$ 50 ppm

V_3 - sucrose 3% + $CoCl_2$ 100 ppm

3.2.3.2 Observations recorded

3.2.3.2.1 Vase life of the spike

The day from harvest till the day on which the last floret fully opened on it was noted to find the vase life in days for the spike.

3.2.3.2.2 Fresh weight

Immediately after harvest the fresh weight in grams was recorded.

3.2.3.2.3 Rate of solution absorption

Total amount of solution absorbed by each spike was found out by measuring the initial and final volume of the holding solution, and it in turn was divided by the number of days in vase to record the rate of water absorption millilitre/day.

3.2.3.2.4 Postharvest loss of weight

The postharvest loss of weight was calculated from the fresh weight of the spike and the weight at the end of its vase life and recorded in grams.

3.2.3.2.5 Number of florets opened at a time

Number of florets that could open at a time was noted.

3.3 Statistical analysis

Data pertaining to each character, were tabulated separately and subjected to appropriate statistical analysis using the MSTATC package available at the Central Computer Facility of the College of Horticulture.

Results

4. RESULTS

The experimental results obtained from the study on the effect of bioregulators on growth, flowering and postharvest life of crossandra are presented here.

4.1 Vegetative characters

The vegetative characters studied were height of the plant, plant spread, number of leaves produced, leaf characters, viz., length, width and leaf area, number of branches and pest or disease incidence.

4.1.1 Height of the plant

Variation in the plant height after the application of bioregulators is presented in Table 1 and Fig.1. It was found that there was significant difference in plant height after bioregulator application (Plates 1, 2 and 3).

Two months after planting (one month after the first application of bioregulators) itself GA treatments recorded maximum height (21 cm in GA 200 ppm treatment to 24.3 cm in GA 100 ppm + 1% urea compared to 13.3 cm and 13.4 cm in the two controls), which was significantly different from all other treatments except BA 100 ppm. The effect of GA on increasing plant height continued to be the same through out the growth period. Among the GA treatments, GA 200 ppm treatment gave plants with maximum height from four months after planting (42.8 cm) and it continued to be the same upto 12 months after planting (71.5 cm).

Table 1. Effect of bioregulators on plant height of crossandra at bimonthly intervals

Treatments	Plant height (cm)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	21.4^{b}	39.3^{a}	43.5^{b}	44.5^{b}	44.6^{b}	51.3^{bc}
T_2	24.3^{a}	39.0^{a}	45.0^{b}	46.5^{b}	46.8^{b}	51.3^{bc}
T_3	21.0^{b}	42.8^{a}	55.4^{a}	59.5^{a}	65.3^{a}	71.5^{a}
T_4	24.0^{a}	37.0^{a}	41.5^{b}	42.6^{b}	48.1^{b}	52.5^{b}
T_5	19.5^{b}	30.6^{b}	34.9^{c}	38.4^{bc}	41.8^{b}	45.3^{cd}
T_6	14.5^{cde}	18.5^{de}	19.9^{f}	20.1^{e}	22.6^{e}	29.8^{g}
T_7	16.1^{c}	25.4^{bc}	32.4^{cd}	33.0^{c}	34.6^{c}	40.9^{de}
T_8	15.2^{cd}	24.2^{cd}	27.3^{de}	31.0^{cd}	31.8^{cd}	37.1^{ef}
T_9	9.9^{g}	9.9^{f}	9.9^{g}	9.9^{f}	10.0^{f}	13.8^{h}
T_{10}	10.6^{fg}	10.8^{f}	10.8^{g}	10.9^{f}	10.9^{f}	15.8^{h}
T_{11}	10.6^{fg}	10.6^{f}	10.8^{g}	10.9^{f}	11.0^{f}	16.9^{h}
T_{12}	10.5^{fg}	10.5^{f}	10.6^{g}	10.8^{f}	10.9^{f}	14.8^{h}
T_{13}	12.7^{def}	17.2^{e}	18.9^{f}	20.5^{e}	25.4^{de}	32.5^{fg}
T_{14}	12.8^{def}	19.2^{de}	20.8^{ef}	21.9^{de}	23.6^{e}	30.3^{fg}
T_{15}	13.6^{cde}	18.0^{de}	19.0^{f}	22.1^{de}	24.5^{e}	31.5^{fg}
T_{16}	12.3^{efg}	16.8^{e}	17.9^{f}	22.8^{de}	23.9^{e}	31.5^{fg}
T_{17}	14.2^{cde}	21.2^{cde}	22.7^{ef}	23.5^{de}	23.8^{e}	30.6^{fg}
T_{18}	13.6^{cde}	17.5^{e}	18.6^{f}	21.9^{de}	22.6^{e}	29.0^{g}
T_{19}	13.5^{cde}	18.4^{de}	20.7^{ef}	22.3^{de}	22.3^{e}	27.6^{g}
T_{20}	13.2^{de}	18.0^{de}	18.8^{f}	19.3^{e}	19.3^{e}	27.5^{g}
$T_{0(1)}$	13.3^{de}	18.6^{de}	21.0^{ef}	23.0^{de}	26.3^{de}	32.0^{fg}
$T_{0(2)}$	13.4^{de}	18.1^{de}	20.8^{ef}	22.8^{de}	24.0^{e}	29.1^{g}

Grouping was done by Duncan's Multiple Range Test
MAP - months after planting

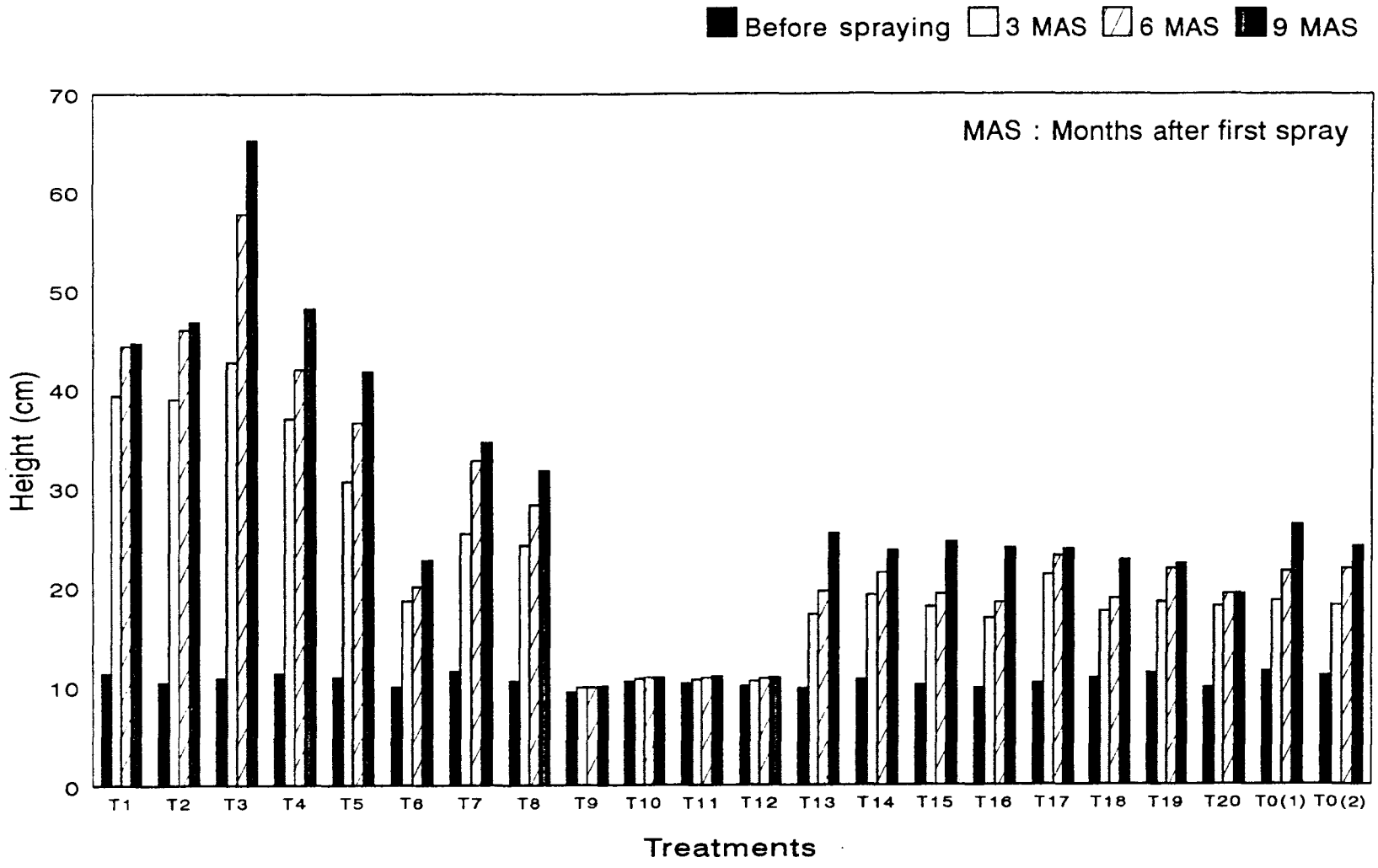

Fig.1. Effect of different bioregulators on the plant height of crossandra at an interval of three months

Plate 1. Plant treated with GA 200 ppm

Plate 2. Plant treated with BA 200 ppm + 1% urea


T3

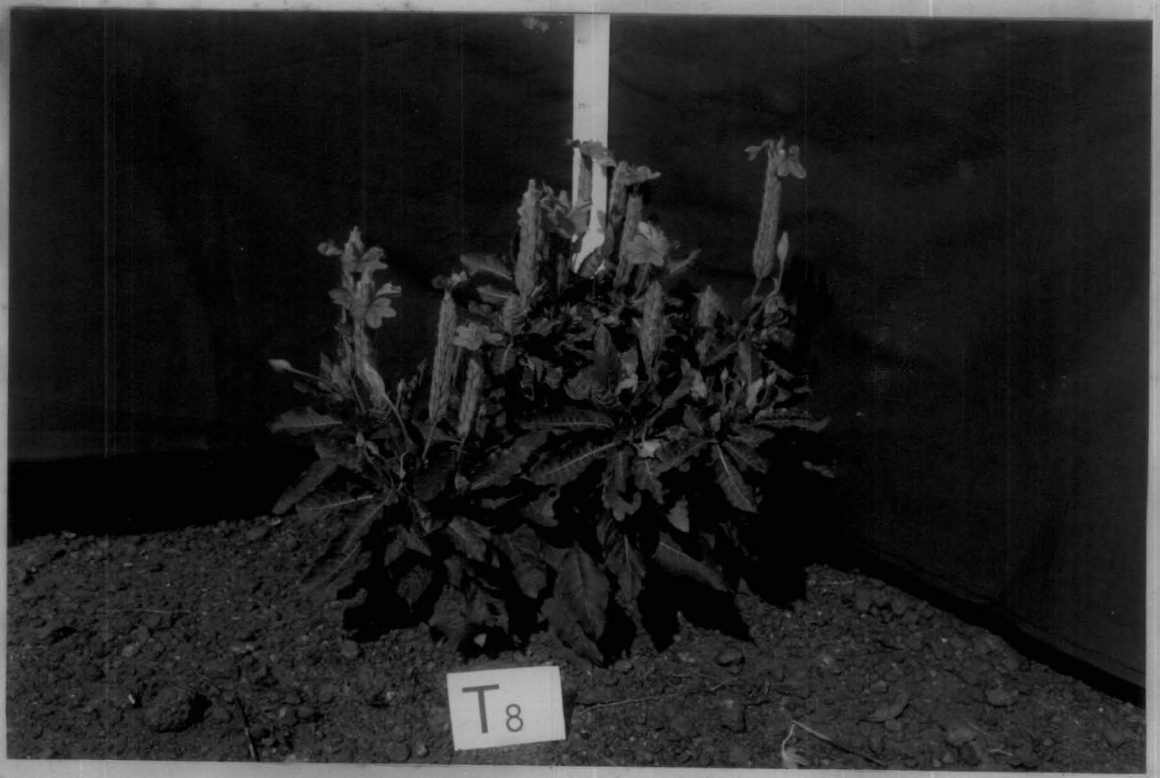
T8

Plate 3. Plants treated with paclobutrazol


15
10
T9


20
15
10
T10

From fifth month onwards, it showed statistically significant difference from other GA treatments also.

Among the BA treatments maximum height increment was recorded for BA 100 ppm (19.5 cm at 2 months after planting to 45.3 cm at 12 months after planting). Plants which received $ZnSO_4$ and CCC containing treatments showed no significant difference from controls through out the study period, irrespective of their concentrations and combinations with 1 per cent urea.

In the case of paclobutrazol, the height remained significantly lower throughout the study period and the height increment was almost nil upto 10 months after planting. Among the paclobutrazol containing treatments there was no significant difference in plant height.

4.1.2 Plant spread

Plant spread recorded was more for all the GA containing treatments at two months after planting (Table 2). GA 200 ppm and GA 200 ppm + 1% urea treatments recorded maximum plant spread during this period (622.7 cm^2 and 609.7 cm^2, respectively).

From 6 months after planting onwards GA 200 ppm and GA 100 ppm (T_1) showed significant difference from both controls (2106.1 cm^2 and 1611.8 cm^2, respectively compared with 917.6 cm^2 and 960.9 cm^2 in the two controls). GA 200 ppm (T_3) recorded maximum plant spread compared to all other treatments at 8 months and 10 months after planting.

Table 2. Effect of bioregulators on the plant spread of crossandra at bimonthly intervals

Treatments	Plant spread (cm^2)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	560.8 (23.6)^{ab}	1314.5 (36.2)^{abc}	1611.8 (40.2)^{b}	1815.2 (42.6)^{b}	2024.2 (45.0)^{b}	2440.5 (49.4)^{b}
T_2	563.7 (23.7)^{ab}	871.6 (29.5)^{def}	1019.7 (31.9)^{cde}	1043.4 (32.3)^{de}	1257.4 (35.5)^{de}	1632.6 (40.4)^{cde}
T_3	622.7 (25.0)^{a}	1259.7 (35.3)^{abcd}	2106.1 (45.9)^{a}	2583.0 (50.8)^{a}	2756.2 (52.5)^{a}	3852.8 (62.1)^{a}
T_4	609.7 (24.7)^{a}	984.6 (31.4)^{bcde}	1202.1 (34.7)^{bcd}	1473.5 (38.3)^{bc}	1670.1 (40.7)^{bc}	2383.5 (48.7)^{b}
T_5	583.8 (24.1)^{ab}	1392.8 (37.2)^{ab}	1546.0 (39.2)^{b}	1629.2 (40.3)^{b}	1672.2 (40.8)^{bc}	2201.5 (46.9)^{bc}
T_6	397.8 (19.9)^{abcd}	788.9 (28.1)^{ef}	930.8 (34.0)^{de}	1005.4 (31.6)^{de}	1049.7 (32.3)^{ef}	1463.0 (38.2)^{de}
T_7	428.1 (20.6)^{abcd}	930.5 (30.4)^{cde}	1332.4 (36.5)^{bc}	1385.6 (37.2)^{bcd}	1454.1 (38.1)^{cd}	1856.3 (43.1)^{bcd}
T_8	561.2 (23.2)^{abc}	1664.8 (40.7)^{a}	2144.6 (46.2)^{a}	2445.1 (49.4)^{a}	2695.0 (51.9)^{a}	4100.0 (63.8)^{a}
T_9	295.0 (17.2)^{cdef}	535.2 (23.1)^{fg}	603.6 (24.6)^{fg}	607.3 (24.6)^{fg}	636.1 (25.2)^{gh}	914.5 (30.2)^{f}
T_{10}	259.9 (16.1)^{def}	360.6. (19.0)^{gh}	400.4 (20.0)^{gh}	423.5 (20.6)^{gh}	436.3 (20.9)^{hi}	550.5 (23.4)^{g}
T_{11}	159.5 (12.6)^{f}	220.8 (14.9)^{h}	275.7 (16.6)^{h}	275.7 (16.6)^{h}	299.6 (17.3)^{i}	412.3 (20.3)^{g}
T_{12}	169.4 (13.0)^{ef}	253.2 (15.9)^{h}	327.9 (18.1)^{h}	330.4 (18.2)^{h}	341.1 (18.4)^{i}	441.6 (21.0)^{g}
T_{13}	458.0 (21.4)^{abcd}	796.1 (28.1)^{ef}	988.4 (31.3)^{cde}	1015.2 (31.7)^{de}	1062.9 (32.5)^{ef}	1279.5 (35.7)^{ef}
T_{14}	355.2 (18.8)^{abcde}	775.4 (27.8)^{ef}	895.0 (29.9)^{def}	940.9 (30.7)^{e}	975.9 (31.2)^{ef}	1585.3 (39.8)^{de}
T_{15}	333.6 (18.3)^{bcdef}	917.4 (30.3)^{cde}	1043.0 (32.2)^{cde}	1098.4 (33.0)^{cde}	1113.8 (33.3)^{def}	1739.3 (41.7)^{cde}
T_{16}	442.8 (21.0)^{abcd}	998.8 (31.4)^{bcde}	1031.9 (32.0)^{cde}	1077.8 (32.7)^{de}	1109.5 (33.1)^{def}	1521.5 (38.9)^{de}
T_{17}	363.9 (18.9)^{abcde}	720.7 (26.8)^{ef}	812.7 (28.5)^{ef}	845.1 (29.1)^{ef}	822.7 (28.7)^{fg}	1259.3 (35.5)^{ef}
T_{18}	411.1 (20.1)^{abcd}	1002.0 (31.5)^{bcde}	1017.5 (31.8)^{cde}	1052.9 (32.4)^{de}	1053.0 (32.4)^{ef}	1428.1 (37.8)^{de}
T_{19}	433.5 (20.8)^{abcd}	773.6 (27.8)^{ef}	842.1 (29.0)^{def}	948.7 (30.8)^{e}	966.0 (31.1)^{ef}	1277.8 (35.7)^{ef}
T_{20}	441.6 (20.9)^{abcd}	718.7 (26.8)^{ef}	847.6 (29.0)^{def}	856.6 (29.1)^{ef}	868.0 (29.4)^{fg}	1416.6 (37.4)^{de}
$T_{0(1)}$	351.1 (18.7)^{abcdef}	799.2 (28.2)^{ef}	917.6 (30.2)^{def}	966.0 (31.1)^{e}	993.3 (31.5)^{ef}	1440.8 (37.8)^{de}
$T_{0(2)}$	336.6 (18.3)^{bcdef}	906.4 (30.1)^{cde}	960.9 (31.0)^{cde}	1000.0 (31.6)^{de}	1044.0 (32.3)^{ef}	1468.4 (38.3)^{de}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting
Transformed values are shown in brackets

From four months after planting onwards BA 200 ppm + 1% urea showed maximum plant spread (1664.8 cm^2 at 4 months after planting to 4100 cm^2 at 12 months after planting) among all the treatments, except at 8 months and 10 months after planting.

In the case of paclobutrazol containing treatments, plant spread was lower even from 2 months after palnting (159.5 cm^2 in paclobutrazol 250 ppm to 295 cm^2 in paclobutrazol 500 ppm compared to 351.1 cm^2 and 336.6 cm^2 in controls, but the difference became significant compared to the controls from 4 months after planting onwards. Among the paclobutrazol containing treatments, paclobutrazol 500 ppm maintained a higher value for plant spread throughout the study period.

For all the $ZnSO_4$ and CCC containing treatments, no significant difference in plant spread was observed compared with controls.

4.1.3 Number of leaves

A significant difference in the number of leaves was observed among the treatments immediately after the application of bioregulators (Table 3). From four months after planting onwards maximum number of leaves were recorded in BA - 200 ppm + 1% urea treatment.

Four months after planting onwards, almost all the paclobutrazol containing treatments recorded lower number of leaves, and from six months after planting, most of them showed significant difference from controls.

When the GA containing treatments were considered GA 100 ppm recorded maximum number of leaves at 2 months after planting (91) and differed

Table 3. Number of leaves in crossandra as influenced by bioregulator treatments

Treatments	2MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	91.0 (9.5)^{a}	130.0 (11.4)^{ab}	193.5 (13.9)^{ab}	177.0 (13.3)^{b}	128.0 (11.3)^{def}	151.5 (12.3)^{cde}
T_2	52.0 (7.2)^{bc}	80.5 (9.0)^{bcde}	101.0 (10.0)^{cdef}	123.0 (11.1)^{c}	78.5 (8.9)^{fghij}	133.5 (11.6)^{cdef}
T_3	51.0 (7.1)^{bc}	162.5 (12.7)^{a}	172.5 (13.1)^{b}	215.5 (14.7)^{ab}	252.5 (15.9)^{ab}	310.5 (17.4)^{ab}
T_4	48.5 (7.0)^{bcd}	99.0 (9.9)^{bcde}	120.0 (11.0)^{cd}	112.5 (10.6)^{cd}	140.5 (11.9)^{cde}	194.0 (13.9)^{bcd}
T_5	53.0 (7.2)^{bc}	176.0 (13.2)^{a}	136.5 (11.7)^{c}	187.5 (13.7)^{b}	196.0 (13.9)^{bc}	178.0 (13.0)^{cde}
T_6	39.5 (6.3)^{bcd}	76.0 (8.7)^{cde}	91.5 (9.6)^{defg}	80.5 (9.0)^{def}	101.5 (10.1)^{efg}	116.0 (10.8)^{cdefg}
T_7	55.5 (7.5)^{b}	101.5 (10.1)^{bcd}	103.0 (10.1)^{cdef}	94.5 (9.7)^{cdef}	175.0 (13.0)^{cd}	159.5 (12.5)^{cde}
T_8	51.0 (7.1)^{bcd}	184.0 (13.4)^{a}	234.5 (15.3)^{a}	225.5 (16.0)^{a}	271.0 (16.5)^{a}	370.0 (19.0)^{a}
T_9	49.5 (7.4)^{bcd}	75.5 (8.7)^{cde}	50.00 (7.0)^{hi}	36.5 (6.0)^{i}	67.5 (8.2)^{ghij}	76.0 (8.7)^{efg}
T_{10}	42.0 (6.5)^{bcd}	36.5 (6.0)^{fg}	49.5 (7.0)^{hi}	47.0 (6.9)^{ghi}	52.0 (7.2)^{hij}	100.0 (10.0)^{cdefg}
T_{11}	32.0 (5.7)^{d}	33.0 (5.7)^{g}	42.5 (6.5)^{i}	41.5 (6.4)^{hi}	47.5 (6.9)^{ij}	49.00 (7.0)^{g}
T_{12}	33.5 (5.8)^{cd}	45.5 (6.7)^{efg}	41.5 (6.4)^{i}	36.0 (6.0)^{i}	44.0 (6.6)^{i}	54.5 (7.4)^{fg}
T_{13}	41.0 (6.4)^{bcd}	120.5 (11.0)^{abc}	133.5 (11.6)^{c}	173.0 (13.1)^{b}	105.0 (10.2)^{efg}	139.5 (11.8)^{cdef}
T_{14}	37.5 (6.1)^{bcd}	67.5 (8.2)^{defg}	71.0 (8.4)^{gh}	118.5 (10.9)^{c}	95.0 (9.7)^{efgh}	209.5 (14.5)^{bc}
T_{15}	35.5 (6.0)^{cd}	63.0 (7.9)^{defg}	110.5 (10.5)^{cde}	75.5 (8.6)^{ef}	82.0 (9.1)^{fghij}	124.0 (11.1)^{cdefg}
T_{16}	34.5 (5.9)^{cd}	73.5 (8.5)^{cdef}	120.00 (11.0)^{cd}	130.5 (10.1)^{cde}	127.5 (11.3)^{def}	176.0 (13.1)^{cde}
T_{17}	36.5 (6.0)^{bcd}	76.0 (8.6)^{cdef}	114.0 (10.7)^{cde}	76.5 (8.8)^{ef}	89.5 (9.4)^{efghi}	132.5 (11.5)^{cdef}
T_{18}	52.5 (7.3)^{bc}	76.0 (8.7)^{cde}	106.0 (10.3)^{cdef}	69.5 (8.3)^{efg}	93.5 (9.6)^{efgh}	95.5 (9.8)^{defg}
T_{19}	37.0 (6.1)^{bcd}	75.0 (8.6)^{cde}	105.5 (10.3)^{cdef}	99.5 (10.0)^{cde}	120.0 (11.0)^{defg}	123.5 (11.1)^{cdefg}
T_{20}	41.5 (6.4)^{bcd}	67.5 (8.2)^{defg}	76.5 (8.7)^{fg}	64.5 (8.0)^{fgh}	82.0 (9.0)^{fghij}	136.5 (11.7)^{cdef}
$T_{0(1)}$	37.0 (6.1)^{bcd}	87.0 (9.3)^{bcde}	76.5 (8.7)^{fg}	90.00 (9.5)^{cdef}	106.5 (10.3)^{efg}	140.5 (11.9)^{cde}
$T_{0(2)}$	34.5 (5.9)^{cd}	64.0 (8.0)^{defg}	86.5 (9.3)^{efg}	116.5 (10.8)^{cd}	127.0 (11.3)^{def}	142.5 (11.9)^{cde}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting
Transformed values are shown in brackets

significantly from all others. Later, from 4 months after planting both GA 100 ppm and GA 200 ppm recorded significantly higher number of leaves (130 and 162.5 respectively at 4 months after planting) compared to controls (87 and 64 at 4 months after planting) GA 200 ppm continued the effect till 12 months after planting (310.5), but GA 100 ppm recorded lower number of leaves during 10 months and 12 months after planting. Other two GA containing treatments showed no significant difference from controls through out the study period.

BA 200 ppm + 1% urea recorded maximum number of leaves from 4 months after planting (184) and continued to possess the effect till 12 months after planting (370). BA 100 ppm also showed a positive effect on the number of leaves produced.

CCC and $ZnSO_4$ containing treatments showed no significant difference from controls throughout the study period.

4.1.4 Leaf characters

4.1.4.1 Leaf length

Immediately after the bioregulator spray GA 100 ppm + 1% urea produced longer leaves (10.8 cm compared to 7.8 and 8.2 cm in the two controls). All GA containing treatments at 6 months after planting and GA 100 ppm and GA 200 ppm at 8 months after planting showed significant positive effect on leaf length. Plants sprayed with GA 200 ppm and GA 200 ppm + 1% urea continued to have longer leaves till 10 months after planting (Table 4).

BA 200 ppm + 1% urea had the maximum leaf length upto 4 months after planting, but later it decreased and showed no significant difference from

Table 4. Effect of bioregulators on the leaf characters of crossandra - Effect on leaf length at bimonthly intervals

Treatments	Leaf length (cm)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	8.9^{bcdef}	7.5^{bc}	8.1^{a}	6.0^{a}	5.3^{bcd}	6.0^{g}
T_2	10.8^{a}	6.9^{bcd}	7.1^{bcd}	5.5^{abc}	4.1^{efg}	6.3^{g}
T_3	9.2^{abcde}	7.3^{bcd}	7.7^{ab}	6.0^{a}	6.1^{ab}	7.0^{f}
T_4	9.8^{abc}	6.8^{bcd}	7.3^{abc}	5.9^{ab}	6.6^{a}	7.2^{ef}
T_5	9.6^{abcd}	6.9^{bcd}	6.7^{cdef}	5.5^{abc}	5.4^{bcd}	7.0^{f}
T_6	8.3^{cdefg}	6.4^{d}	6.2^{defgh}	5.1^{bcd}	4.8^{de}	6.9^{f}
T_7	7.0^{g}	6.7^{b}	6.8^{bcde}	5.0^{cde}	5.6^{abcd}	6.9^{f}
T_8	9.9^{ab}	8.7^{a}	6.3^{cdefg}	5.5^{abc}	5.9^{abc}	8.1^{ab}
T_9	5.0^{h}	6.7^{bcd}	4.0^{j}	3.6^{ij}	5.2^{bcd}	5.2^{hi}
T_{10}	5.4^{h}	4.2^{e}	4.2^{j}	3.1^{j}	4.1^{ef}	5.4^{h}
T_{11}	4.3^{h}	4.2^{e}	3.9^{j}	4.1^{efghi}	3.1^{fg}	5.0^{i}
T_{12}	4.7^{h}	3.6^{e}	3.7^{j}	3.6^{ij}	3.1^{g}	4.9^{i}
T_{13}	8.5^{bcdefg}	6.5^{cd}	5.2^{i}	4.1^{fghi}	5.4^{bcd}	5.9^{g}
T_{14}	7.8^{efg}	7.2^{bcd}	5.9^{efghi}	4.6^{defg}	5.0^{cde}	7.5^{cde}
T_{15}	7.0^{g}	6.6^{cd}	5.4^{ghi}	4.2^{defghi}	5.3^{bcd}	7.8^{bcd}
T_{16}	7.5^{fg}	6.9^{bcd}	5.5^{ghi}	4.6^{defgh}	5.0^{cde}	8.0^{abc}
T_{17}	9.4^{abcde}	6.8^{bcd}	5.3^{hi}	3.9^{ghi}	4.9^{de}	8.0^{abc}
T_{18}	7.4^{fg}	6.7^{bcd}	5.4^{ghi}	3.8^{hij}	5.3^{bcd}	7.3^{def}
T_{19}	8.4^{bcdefg}	6.8^{bcd}	5.2^{i}	3.8^{ghij}	2.5^{bcd}	8.1^{ab}
T_{20}	8.0^{defg}	7.0^{bcd}	5.6^{ghi}	4.2^{efghi}	6.0^{abc}	8.4^{a}
$T_{0(1)}$	7.8^{efg}	7.1^{bcd}	6.0^{efghi}	4.9^{cdef}	5.6^{abcd}	7.9^{abc}
$T_{0(2)}$	8.2^{defg}	6.6^{bcd}	5.8^{fghi}	5.1^{bcd}	5.3^{bcd}	7.7^{bcde}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting

control during the later period. BA 100 ppm + 1% urea and BA 200 ppm showed no significant difference from control almost throughout the year except May and June.

Leaf length of all the paclobutrazol containing treatments remained significantly lower than controls till 10 months after planting; except for paclobutrazol 500 ppm, for which the length of leaf was on par with control during certain months.

4.1.4.2 Leaf width

Significant variation in the leaf width was noticed throughout the study period (Table 5). Like leaf length plants treated with GA and its combinations produced wider leaves. All the paclobutrazol containing treatments produced leaves with lower width and the difference was found to be significantly lower than the controls during certain months of the year. In certain months CCC 500 ppm also produced narrower leaves.

4.1.4.3 Leaf area

Variation in the leaf area at bimonthly intervals is shown in Table 6.

In the case of GA containing treatments, GA 100 ppm (2461 cm^2), GA 200 ppm (1909 cm^2) and GA 200 pm + 1% urea (1356 cm^2) recorded significantly higher leaf area compared to both controls upto 6 months after planting, but for the latter the difference became insignificant at 8 months after planting. Only GA 200 ppm continued to have significantly higher leaf area till 12 months after planting.

Table 5. Effect of bioregulators on the leaf characters of crossandra - Effect on leaf width at bimonthly intervals

Treatments	Leaf breadth (cm)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	3.3^{cdef}	2.7^{abcd}	2.9^{a}	2.3^{ab}	2.5^{abcd}	3.0^{abcde}
T_2	3.5^{bcde}	2.6^{cd}	2.7^{ab}	2.1^{abcde}	2.5^{abcd}	2.8^{cdef}
T_3	3.2^{efg}	2.5^{cde}	2.6^{ab}	2.3^{ab}	2.9^{a}	3.3^{abc}
T_4	2.6^{ghi}	2.3^{cde}	2.8^{a}	2.6^{a}	2.3^{bcd}	2.6^{ef}
T_5	4.1^{a}	2.7^{abcd}	2.7^{ab}	2.0^{bcdefg}	2.4^{abcd}	2.9^{bcdef}
T_6	3.1^{efgh}	2.9^{abcd}	2.6^{ab}	2.3^{ab}	2.3^{bcd}	2.6^{ef}
T_7	3.2^{efg}	3.3^{ab}	2.7^{ab}	2.1^{abcde}	2.5^{abcd}	3.2^{abcd}
T_8	4.0^{ab}	3.4^{a}	2.7^{ab}	2.2^{abcd}	2.7^{ab}	3.4^{a}
T_9	2.5^{hi}	2.4^{cde}	2.1^{abcd}	1.8^{cdefg}	2.2^{bcd}	2.9^{bcdef}
T_{10}	2.7^{fghi}	2.3^{cde}	2.0^{bcd}	1.8^{cdefg}	1.9^{de}	2.8^{def}
T_{11}	2.2^{i}	1.9^{e}	1.6^{d}	1.8^{cdefg}	1.6^{e}	2.6^{ef}
T_{12}	1.9^{i}	2.8^{abcd}	1.8^{cd}	1.7^{fg}	1.6^{e}	2.5^{f}
T_{13}	3.6^{abcde}	2.6^{bcd}	2.0^{bcd}	1.7^{fg}	2.3^{bcd}	3.1^{ab}
T_{14}	3.3^{def}	3.0^{abc}	2.3^{abcd}	1.8^{cdefg}	2.3^{bcd}	3.2^{abcd}
T_{15}	3.2^{efg}	2.2^{de}	2.5^{abc}	1.9^{bcdefg}	2.0^{cde}	2.9^{bcdef}
T_{16}	3.5^{bcde}	2.5^{cde}	2.4^{abc}	2.0^{bcdefg}	2.4^{abcd}	3.4^{a}
T_{17}	3.5^{bcde}	2.8^{abcd}	2.2^{abcd}	1.7^{fg}	2.4^{abcd}	3.3^{abc}
T_{18}	3.8^{abcd}	2.9^{abcd}	2.3^{abcd}	1.7^{fg}	2.3^{bcd}	3.3^{abc}
T_{19}	3.9^{abc}	2.7^{abcd}	2.2^{abcd}	1.8^{cdefg}	2.4^{abcd}	3.0^{abcde}
T_{20}	3.8^{abcd}	2.9^{abcd}	2.5^{ab}	2.0^{bcdefg}	2.7^{ab}	3.2^{abcd}
$T_{0(1)}$	3.5^{bcde}	2.4^{cde}	2.4^{abc}	2.2^{abc}	2.5^{abcd}	3.1^{abcd}
$T_{0(2)}$	3.8^{abcd}	2.7^{abcd}	2.7^{ab}	2.2^{abc}	2.6^{abc}	3.2^{abcd}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting

Table 6. Effect of bioregulators on the leaf characters of crossandra - Effect on leaf area at bimonthly intervals

Treat-ments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	1502^{a}	1467^{bc}	2461^{a}	1394^{abc}	928.3^{bcd}	1493^{cde}
T_2	1083^{abcd}	791.4^{bcd}	1032^{cdef}	797.7^{cdef}	452.3^{def}	1297^{cde}
T_3	832.4^{bcde}	1634^{bc}	1909^{b}	1654^{ab}	2442^{a}	3972^{ab}
T_4	693.2^{bcdef}	884.9^{bcd}	1356^{cd}	944.4^{cde}	1180^{bc}	1989^{cde}
T_5	1229^{ab}	1807^{b}	1383^{c}	1168^{bcd}	1430^{b}	1970^{cde}
T_6	565.4^{cdef}	783.9^{bcd}	810.5^{ef}	534.4^{efgh}	621.3^{cdef}	1126^{cde}
T_7	683.2^{bcdef}	1415^{bc}	1070^{cde}	544.7^{efgh}	1394^{b}	1917^{cde}
T_8	1134^{abc}	3159^{a}	2238^{ab}	1746^{a}	2358^{a}	5633^{a}
T_9	294.2^{ef}	703.3^{cd}	242.6^{ghi}	133.8^{h}	434.0^{def}	631.5^{de}
T_{10}	346.9^{ef}	194.5^{d}	232.0^{hi}	139.5^{h}	220.7^{ef}	820.3^{cde}
T_{11}	171.6^{f}	140.7^{d}	153.1^{i}	175.6^{gh}	128.3^{f}	348.2^{e}
T_{12}	190.1^{f}	248.4^{d}	153.1^{i}	121.3^{h}	117.6^{f}	368.0^{e}
T_{13}	707.7^{bcdef}	1148^{bcd}	770.7^{ef}	655.4^{defgh}	710.0^{cdef}	1496^{cde}
T_{14}	525.4^{def}	799.5^{bcd}	516.4^{fghi}	547.5^{efgh}	622.6^{cdef}	2747^{bc}
T_{15}	436.1^{ef}	537.5^{cd}	814.3^{ef}	342.6^{fgh}	500.4^{cdef}	1554^{cde}
T_{16}	498.8^{def}	693.8^{cd}	876.2^{def}	522.2^{efgh}	865.9^{bcde}	2622^{bcd}
T_{17}	687.6^{bcdef}	852.0^{bcd}	764.9^{ef}	289.2^{fgh}	564.3^{cdef}	1884^{cde}
T_{18}	811.1^{bcde}	832.9^{bcd}	734.5^{efgh}	250.2^{fgh}	654.3^{cdef}	1254^{cde}
T_{19}	668.4^{bcdef}	756.5^{bcd}	653.0^{efghi}	369.4^{fgh}	860.1^{bcde}	1663^{cde}
T_{20}	692.6^{bcdef}	758.0^{bcd}	614.0^{efghi}	302.8^{fgh}	772.8^{bcdef}	2008^{cde}
$T_{0(1)}$	545.8^{cdef}	828.5^{bcd}	613.4^{efghi}	551.0^{efgh}	829.6^{bcde}	1901^{cde}
$T_{0(2)}$	593.8^{cdef}	639.2^{cd}	743.2^{efg}	716.8^{defg}	945.9^{bcd}	1895^{cde}

Grouping was done by Duncan's Multiple Range test
MAP - Months after planting

BA 200 ppm + 1% urea treatment recorded maximum leaf area from 4 months after planting (3159 cm^2) onwards till the end of the study period (5633 cm^2) except at 10 months after planting and the difference was always significant compared to controls. BA 100 ppm recorded significantly higher leaf area only at 6 months after planting (1383 cm^2).

Comparatively lower leaf area was recorded for all the paclobutrazol containing treatments and all the CCC and $ZnSO_4$ containing treatments were on par with either or both of the controls throughout the study period.

4.1.5 Number of branches

Results obtained showed that there was significant difference among the treatments in the production of branches after 2 months of bioregulator spray (3 months after planting).

Table 7 and Fig.2 showed that the GA containing treatments in general produced higher number of branches. Upto 10 months after planting GA 100 ppm and GA 200 ppm showed no significant difference in the number of branches (15.3 and 17.8 at 10 months after planting). After that, GA 200 ppm treatment recorded significantly more number of branches (22.6 at 12 months after planting) and was found to be significantly higher than all the treatments except BA 200 ppm + 1% urea (23.7).

BA had a very significant effect on increasing branching. One month after the treatment itself BA 200 ppm + 1% urea produced significantly more number of branches than non-sprayed controls (4 and 2 respectively) and from 6

Table 7. Effect of bioregulators on the branching habit of crossandra at bimonthly intervals

Treatments	Number of branches					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	4.1^{a}	8.9^{a}	13.3^{a}	14.5^{ab}	15.3^{ab}	18.1^{b}
T_2	2.9^{abc}	5.3^{cd}	7.3^{cdefg}	8.0^{c}	8.0^{fghi}	12.3^{de}
T_3	2.5^{abc}	7.6^{ab}	11.0^{ab}	16.8^{a}	17.8^{a}	22.6^{a}
T_4	3.1^{abc}	5.8^{bc}	9.3^{bcd}	12.0^{b}	13.3^{bcd}	15.9^{bc}
T_5	2.8^{abc}	5.1^{cd}	9.5^{bc}	12.8^{b}	13.5^{bc}	17.5^{b}
T_6	2.4^{bc}	4.4^{cde}	7.5^{cdef}	8.3^{c}	8.3^{fgh}	9.9^{ef}
T_7	2.8^{abc}	6.0^{bc}	8.0^{bcde}	8.5^{c}	10.6^{cdef}	13.5^{cd}
T_8	4.0^{ab}	8.5^{a}	13.8^{a}	16.8^{a}	17.8^{a}	23.7^{a}
T_9	3.1^{abc}	4.0^{cde}	4.3^{ghi}	4.3^{ef}	5.8^{hij}	6.8^{fg}
T_{10}	2.0^{c}	2.5^{e}	3.3^{i}	3.5^{f}	4.4^{j}	5.3^{g}
T_{11}	2.0^{c}	3.0^{de}	3.3^{i}	3.5^{f}	4.3^{j}	4.9^{g}
T_{12}	2.4^{bc}	3.1^{de}	3.5^{hi}	4.5^{ef}	4.8^{ij}	5.0^{g}
T_{13}	2.6^{abc}	5.9^{bc}	6.6^{cdefg}	8.1^{c}	12.5^{bcde}	15.5^{bc}
T_{14}	2.6^{abc}	4.1^{cde}	5.9^{efghi}	8.0^{c}	8.0^{fghi}	10.9^{de}
T_{15}	2.8^{abc}	4.0^{cde}	5.8^{efghi}	6.8^{cde}	7.3^{ghij}	10.0^{ef}
T_{16}	3.1^{abc}	4.3^{cde}	5.6^{efghi}	6.8^{cde}	8.8^{fgh}	10.6^{de}
T_{17}	2.5^{abc}	6.0^{bc}	7.0^{cdefg}	7.0^{cde}	8.0^{fghi}	9.3^{ef}
T_{18}	3.0^{abc}	4.5^{cde}	4.8^{fghi}	5.0^{def}	7.1^{ghij}	9.7^{ef}
T_{19}	2.4^{bc}	4.4^{cde}	5.5^{efghi}	8.5^{c}	9.5^{efg}	10.3^{e}
T_{20}	3.1^{abc}	4.9^{cd}	6.3^{defghi}	7.5^{cd}	8.8^{fgh}	9.5^{ef}
$T_{0(1)}$	2.8^{abc}	4.6^{cde}	7.0^{cdefg}	7.0^{cde}	10.0^{defg}	11.0^{de}
$T_{0(2)}$	2.0^{c}	4.0^{cde}	6.5^{cdefgh}	6.0^{cd}	8.3^{fgh}	9.1^{ef}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting

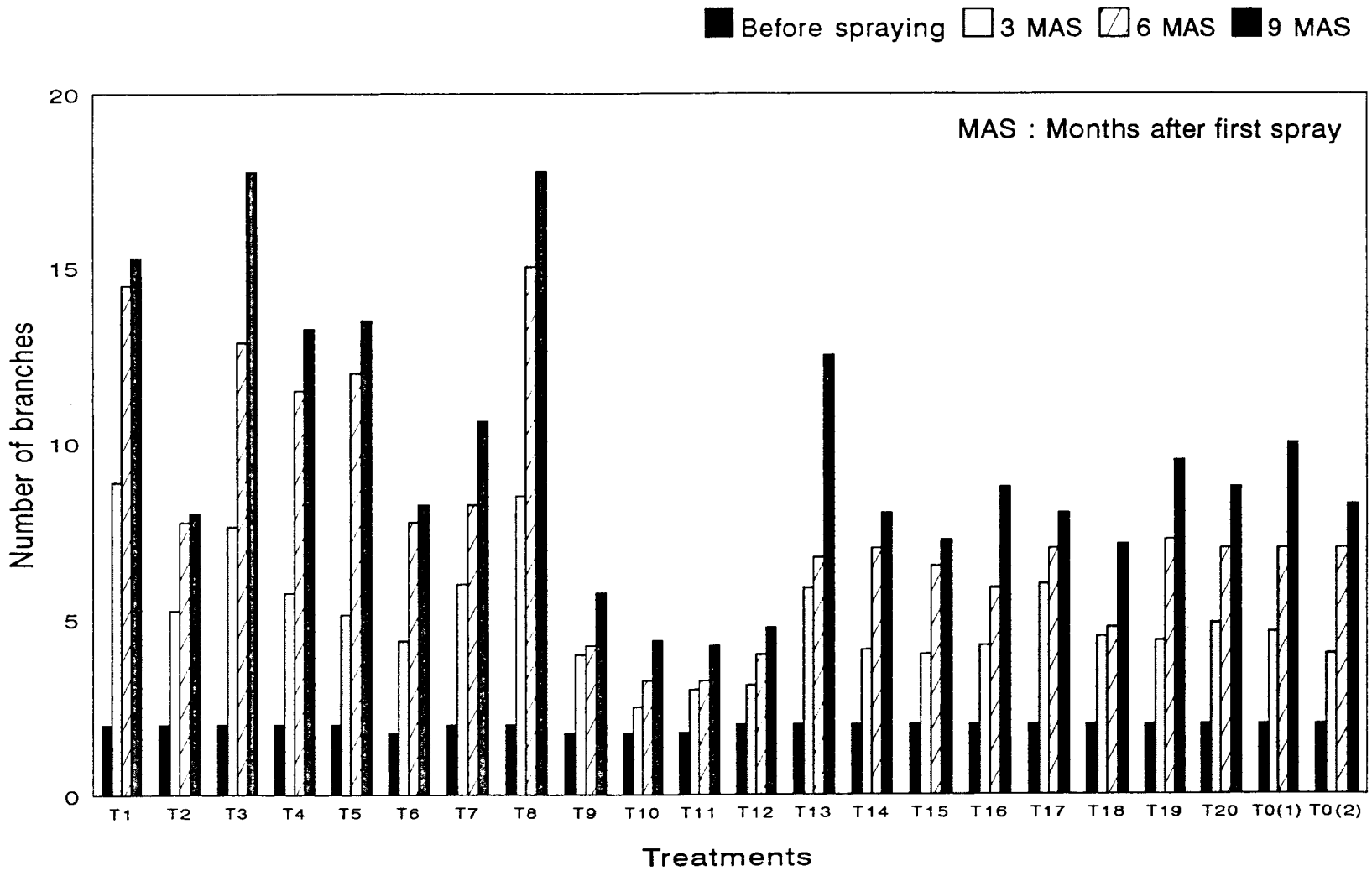

Fig.2. Effect of different bioregulators on the number of branches produced in crossandra at an interval of three months

months after planting onwards it continued to be the one with maximum number of branches (13.8 at 6 months after planting to 23.7 at 12 months after planting). BA 100 ppm showed significantly more number of branches (12) from 8 months after planting compared to controls (6 and 7).

From 10 months after planting onwards CCC 500 ppm showed significantly higher number of branches (12.5 at 10 months after planting) than non-sprayed control (8.3).

From 6 months after planting, paclobutrazol containing treatments showed significantly lowest number of branches throughout the study period.

4.1.6 Pest/disease incidence

During the months of January, February and June, there was incidence of *Helicoverpa armigera*. Which was found to bore into the young unopened inflorescences resulting in partial or no opening of the infested inflorescences. Incidence was seen moderately on BA 200 ppm treatment and mildly on CCC 1000 ppm and water sprayed control during January, February months. During June plots which received BA 200 ppm + 1% urea, GA 100 ppm + 1% urea, GA 200 ppm + 1% urea showed moderate incidence, while the incidence was mild in GA 200 ppm treatment.

4.2 Floral characters

4.2.1 Time taken for the first spike emergence

Significant difference in the number of days for the first spike emergence was noted among the treatments (Fig.3). Maximum advancement in flowering was

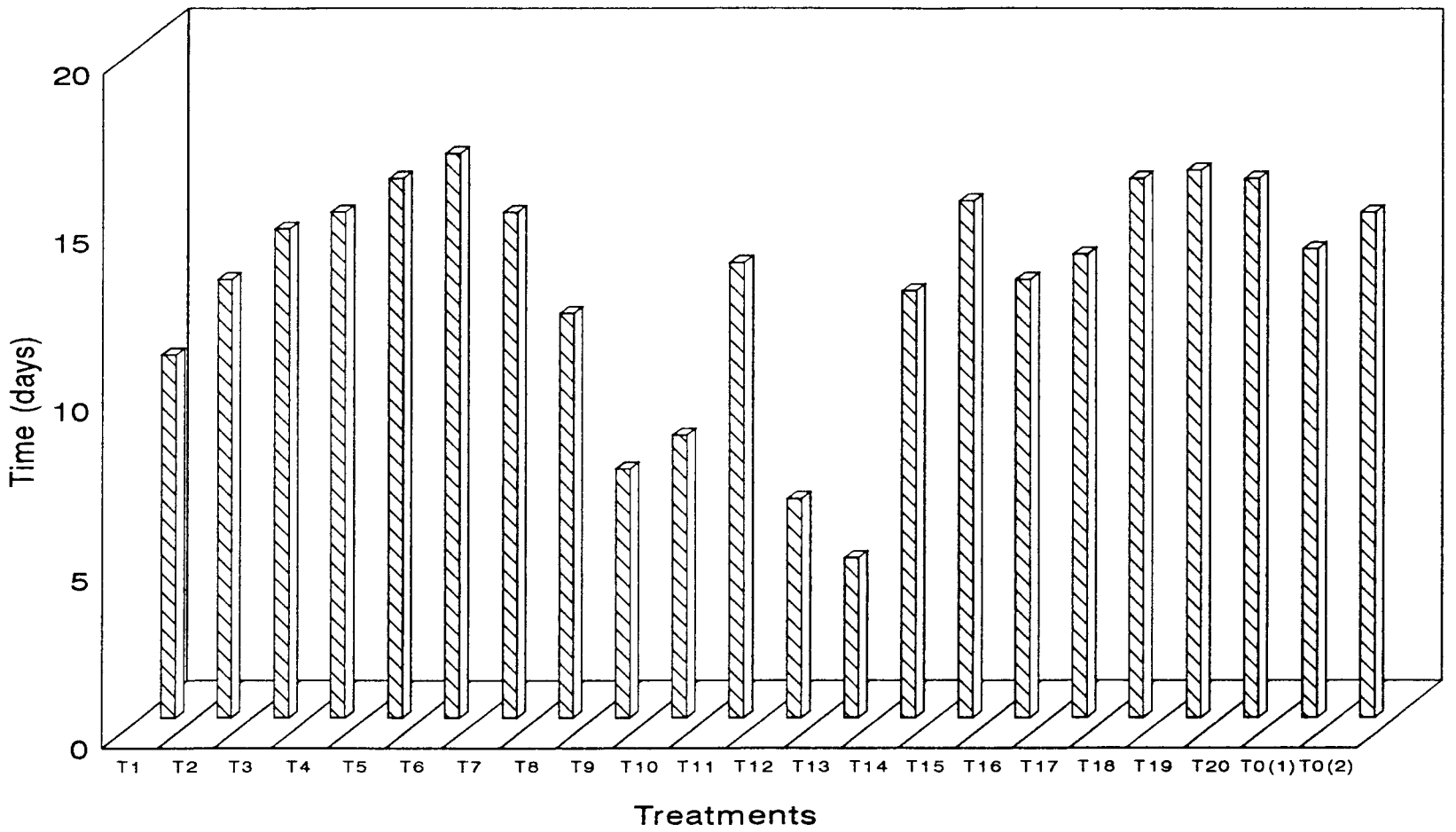

Fig.3. Effect of different bioregulators on the time required for the emergence of the first spike after bioregulator application in crossandra

observed for treatment with CCC 500 ppm (4.8 days after spray). All the paclobutrazol containing treatments except paclobutrazol 500 ppm + 1% urea were found to have no significant difference (6.5 to 8.38 days) and all of them advanced flowering. GA 100 ppm also caused significant advancement in the emergence of first spike (10.8 days) compared with controls.

4.2.2 Time taken for the first floret appearance in a spike

In the case of time taken for the first floret appearance, the effects of field treatments, effect of months and their interaction was found significant

Effect of field treatments

Effect of the field treatments or an average (Table 12) showed significant variation, regarding the time taken for the appearance of the first floret in a spike. Quickest appearance of the first floret, after the emergence of spike was noticed in GA 100 ppm + 1% urea treatment (12.8 days) and maximum delay was noticed in treatment with paclobutrazol 250 ppm + 1% urea treatment (20.6 days). Paclobutrazol 250 ppm (19.6 days) and CCC 500 ppm + 1% urea (18.4 days) also showed much delay.

Effect of different months

Comparing a period of 10 months from September-June it was found that the effect of months has got a significant effect on the emergence of spike in crossandra (Table 11). Quickest appearance of the first floret after the emergence of spike was noticed during May (12.7 days) and maximum delay during September (19.0 days).

Interaction effect

Interaction effect of treatments and months were also significant (Table 8). Minimum time for first floret appearance after the emergence of the spike was recorded for treatments with GA 100 ppm + 1% urea and BA 100 ppm + 1% urea (8.5 days) during March and maximum time for GA 200 ppm + 1% urea during September (30.5 days).

Among different months, GA 200 ppm + 1% urea recorded maximum time for the first floret appearance during September (30.5 days) and this differed significantly from all other treatments. Quickest floret appearance during September was for $ZnSO_4$ 0.5% (13.5 days) and it showed significant difference from non-sprayed control (20.5 days).

During October minimum time for first floret appearance in a spike was recorded for paclobutrazol 500 ppm + 1% urea and $ZnSO_4$ 0.5% (14 days) which was significantly lower than controls (18.3 and 18.8 days) and maximum time for GA 200 ppm + 1% urea (24 days).

During November quickest floret appearance was for BA 100 ppm + 1% urea (11.5 days) and maximum delay for paclobutrazol 250 ppm + 1% urea and it continued the effect in a similar way during December (23 days) and January (20.5 days), but during January the paclobutrazol 250 ppm also took the same time (20.5 days). Quickest floret appearance during December was for GA 200 ppm, GA 200 ppm + 1% urea and BA 100 ppm + 1% urea (13.5 days), and during January for GA 100 ppm + 1% urea and BA 100 ppm + 1% urea (13.3 days).

Table 8. Effect of bioregulator treatments on the time required for the appearance of the first floret in a spike of crossandra (in days) at monthly intervals

Treat-ments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	21.5^{bcde}	18.5^{de}	14.8^{fgh}	15.8^{fg}	12.5^{gh}	12.5^{gh}	11.0^{hi}	12.5^{e}	12.5^{cd}	12.0^{gh}
T_2	18.4^{bcdefg}	17.3^{efg}	14.0^{ghij}	14.5^{gh}	13.3^{g}	9.5^{i}	8.5^{i}	9.0^{g}	10.3^{ghi}	11.8^{h}
T_3	22.7^{bc}	18.8^{de}	12.3^{kl}	13.5^{h}	14.0^{ij}	12.0^{h}	10.5^{hi}	8.8^{g}	9.3^{i}	15.0^{ef}
T_4	30.5^{a}	24.0^{a}	13.8^{hij}	13.5^{h}	15.5^{fg}	13.5^{efgh}	13.3^{fgh}	12.5^{e}	12.3^{cd}	15.5^{de}
T_5	23.6^{b}	19.5^{cd}	13.5^{ij}	14.8^{gh}	14.3^{hij}	14.0^{defg}	10.5^{hi}	10.5^{f}	13.5^{c}	15.5^{de}
T_6	22.5^{bcd}	18.5^{de}	11.5^{l}	13.5^{h}	13.3^{j}	12.6^{fgh}	8.5^{i}	10.5^{f}	12.5^{cd}	9.5^{i}
T_7	20.5^{bcdef}	18.0^{def}	13.0^{jk}	14.8^{gh}	14.3^{hij}	12.3^{gh}	10.5^{hi}	12.3^{e}	11.8^{def}	12.8^{gh}
T_8	21.3^{bcde}	18.8^{de}	13.8^{hij}	15.8^{fg}	14.3^{hij}	12.0^{h}	10.5^{hi}	12.0^{f}	12.0^{de}	13.5^{fg}
T_9	16.1^{efg}	16.0^{g}	17.0^{cd}	17.0^{ef}	17.5^{de}	16.0^{c}	15.5^{fg}	15.5^{c}	15.8^{b}	15.8^{cde}
T_{10}	14.5^{fg}	14.0^{h}	15.0^{efg}	15.0^{g}	15.5^{fg}	12.5^{gh}	12.5^{gh}	12.0^{e}	10.5^{fghi}	15.0^{ef}
T_{11}	16.5^{defg}	16.8^{fg}	15.5^{ef}	20.5^{b}	20.5^{a}	22.5^{a}	27.5^{a}	22.5^{a}	10.5^{fghi}	16.5^{cde}
T_{12}	17.3^{cdefg}	22.5^{b}	20.5^{a}	23.0^{a}	20.5^{a}	20.0^{b}	25.3^{a}	20.5^{b}	20.5^{a}	16.3^{cde}
T_{13}	17.5^{cdefg}	16.3^{g}	17.0^{cd}	15.5^{g}	16.5^{ef}	15.3^{cd}	13.3^{fgh}	11.8^{e}	10.5^{ghi}	16.3^{cde}
T_{14}	18.9^{bcdefg}	20.8^{c}	19.5^{ab}	19.5^{bc}	19.5^{ab}	21.8^{a}	18.5^{cd}	15.3^{cd}	10.8^{efgh}	17.5^{bc}
T_{15}	16.5^{defg}	18.5^{de}	18.5^{b}	19.5^{bc}	19.0^{bc}	19.3^{b}	17.5^{de}	14.3^{d}	11.5^{defg}	19.8^{a}
T_{16}	15.5^{efg}	14.3^{h}	14.3^{ghi}	18.8^{cd}	17.8^{d}	16.6^{c}	15.5^{ef}	14.8^{cd}	12.5^{cd}	17.0^{cd}
T_{17}	16.3^{efg}	16.8^{fg}	17.0^{cd}	17.3^{e}	16.5^{ef}	12.8^{fgh}	11.5^{gh}	11.5^{ef}	10.5^{fghi}	11.5^{h}
T_{18}	21.0^{bcde}	19.5^{cd}	20.5^{a}	19.5^{bc}	18.0^{cd}	16.0^{c}	15.5^{ef}	12.5^{e}	12.8^{cd}	18.8^{ab}
T_{19}	13.5^{g}	14.0^{h}	15.5^{ef}	17.5^{de}	15.3^{efgh}	14.5^{cde}	22.5^{b}	14.3^{d}	$13/5^{c}$	13.0^{gh}
T_{20}	14.3^{g}	14.3^{h}	16.0^{de}	17.5^{de}	14.0^{ij}	14.3^{def}	20.5^{bc}	14.8^{cd}	9.5^{hi}	13.0^{gh}
$T_{0(1)}$	19.0^{bcdefg}	18.3^{de}	17.3^{c}	19.5^{bc}	15.5^{fg}	13.2^{efgh}	12.0^{gh}	12.5^{e}	10.5^{fghi}	17.5^{bc}
$T_{0(2)}$	20.5^{bcdef}	18.8^{de}	19.5^{ab}	19.8^{bc}	15.8^{ff}	14.0^{defg}	12.5^{gh}	12.0^{e}	10.8^{efgh}	16.3^{cde}

Grouping was done by Duncan's Multiple Range Test
MAP - Months after planting

Significant decrease in the time required for first floret appearance was recorded for GA 100 ppm + 1% urea during February (9.5 days), from all other treatments and all CCC treatments except CCC 500 ppm, paclobutrazol 250 ppm with and without urea, paclobutrazol 500 ppm and $ZnSO_4$ 0.25% + 1% urea showed much delay in the first floret appearance after spike emergence.

During March GA and BA each at 100 ppm concentrations with urea caused quickest floret appearance (8.5 days) and maximum delay in floret appearance was for paclobutrazol 250 ppm + 1% urea (25.3 days) and all the three differed significantly from controls (12 days and 12.5 days). Latter showed similar trend during April and May also, but GA 200 ppm recorded quickest appearance of the first floret in a spike during this period (8.8 and 9.5 days respectively). CCC 1000 ppm (19.8 days) caused maximum delay in floret appearance during June and minimum for BA 100 ppm + 1% urea (9.5 days), both differed significantly from most of the other treatments.

4.2.3 Time taken for the opening of a floret

In this case also treatment effect and month effects were significant.

Effect of field treatments

Significant difference among the field treatments were recorded for the time taken for the opening of a floret. Minimum time for floret opening was recorded for paclobutrazol 500 ppm + 1% urea treatment (2.8 days) followed by water sprayed control (2.9 days) and maximum for GA 100 ppm + 1% urea and BA 200 ppm + 1% urea (3.9 days) (Table 12).

Effect of months

From among the months, the difference in time for the opening of a floret was significant, and minimum time was recorded during February (3 days) and maximum during May (4.4 days) (Table 11).

Interaction effect

Time taken for the opening of a floret varied from 2.5 days to 5.5 days and the interaction was significant (Table 9). Maximum time for floret opening was recorded for $ZnSO_4$ 0.5% treatment during September and minimum time for paclobutrazol 500 ppm (during September, December and April), paclobutrazol 500 ppm + 1% urea (during February and April) and water sprayed control(during February)(2.5 days).

During September difference from non-sprayed control (3.5 days) was significant for $ZnSO_4$ 0.5% (5.5 days) and paclobutrazol 500 ppm (2.5 days), but the latter was on par with water sprayed control (3.3 days).

During October, none of the treatments showed significant difference from non-sprayed control, but BA 100 ppm (4.3) showed significantly more time for floret opening compared to water sprayed controls and also compared to $ZnSO_4$ 0.25% with and without urea, and paclobutrazol 500 ppm with and without urea (3 days). Plants treated with BA 100 ppm took more time for floret opening (4.3 days) during November also, and during this time minimum time was recorded for paclobutrazol 250 ppm treatment (2.8 days). During December, no significant difference from controls were noticed but minimum time for floret opening was for

Table 9. Effect of bioregulators on the time taken for the opening of floret (in days) in a spike of crossandra

Treat-ments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	3.5^{bcd}	3.3^{ab}	3.3^{bc}	3.5^{a}	3.3^{a}	3.0^{ab}	3.8^{abcde}	4.3^{ab}	4.8^{ab}	4.3^{a}
T_2	3.8^{bc}	3.8^{ab}	3.3^{bc}	3.8^{a}	3.3^{a}	3.3^{ab}	4.0^{abc}	4.0^{abc}	4.5^{abc}	4.3^{a}
T_3	4.0^{b}	3.5^{ab}	3.8^{ab}	3.3^{ab}	3.5^{a}	3.5^{a}	3.3^{bcde}	3.8^{abcd}	4.0^{abcd}	4.3^{a}
T_4	3.0^{cde}	3.5^{ab}	3.3^{bc}	3.3^{ab}	3.0^{a}	3.0^{ab}	3.8^{abcde}	3.5^{bcde}	4.0^{abcd}	4.0^{ab}
T_5	3.2^{bcde}	4.3^{a}	4.3^{a}	3.3^{ab}	3.3^{a}	3.8^{a}	4.0^{abc}	3.8^{abcd}	4.3^{abcd}	3.5^{ab}
T_6	3.3^{bcde}	3.3^{ab}	3.3^{bc}	3.3^{ab}	3.5^{a}	3.8^{a}	3.8^{abcde}	3.8^{abcd}	4.8^{ab}	3.8^{ab}
T_7	3.5^{bcd}	3.8^{ab}	3.3^{bc}	3.6^{a}	3.0^{a}	3.0^{ab}	3.5^{abcde}	4.0^{abc}	5.0^{a}	3.8^{ab}
T_8	3.7^{bcd}	4.0^{ab}	3.8^{ab}	3.8^{a}	3.3^{a}	3.3^{ab}	3.8^{abcde}	4.5^{a}	4.8^{ab}	4.3^{a}
T_9	2.5^{e}	3.0^{b}	3.1^{bc}	2.5^{b}	3.0^{a}	3.0^{ab}	2.8^{de}	2.5^{f}	3.8^{bcd}	3.5^{ab}
T_{10}	3.3^{bcde}	3.0^{b}	3.3^{bc}	3.0^{ab}	2.8^{a}	2.5^{b}	2.8^{de}	2.5^{f}	3.5^{cd}	3.5^{ab}
T_{11}	2.8^{de}	3.3^{ab}	2.8^{c}	3.0^{ab}	2.9^{a}	3.0^{ab}	3.0^{cde}	2.8^{ef}	3.8^{bcd}	3.3^{b}
T_{12}	3.4^{bcde}	3.1^{ab}	3.0^{bc}	3.3^{ab}	3.0^{a}	3.0^{ab}	3.3^{bcde}	3.0^{def}	3.5^{cd}	3.8^{ab}
T_{13}	3.3^{bcde}	3.3^{ab}	3.3^{bc}	3.3^{ab}	2.8^{a}	2.6^{b}	3.3^{bcde}	3.1^{cdef}	4.3^{abcd}	3.8^{ab}
T_{14}	3.3^{bcde}	3.8^{ab}	3.3^{bc}	3.8^{a}	3.3^{a}	3.8^{a}	4.3^{ab}	3.5^{bcde}	4.3^{abcd}	3.8^{ab}
T_{15}	3.7^{bcd}	3.3^{ab}	3.3^{bc}	3.3^{ab}	3.3^{a}	3.0^{ab}	4.5^{a}	3.5^{bcde}	4.8^{ab}	4.0^{ab}
T_{16}	3.5^{bcd}	3.3^{ab}	3.5^{abc}	3.8^{a}	3.3^{a}	3.3^{ab}	3.9^{abcd}	3.8^{abcd}	4.8^{ab}	3.8^{ab}
T_{17}	3.0^{cde}	3.0^{b}	3.3^{bc}	3.0^{ab}	3.3^{a}	3.0^{ab}	3.0^{cde}	3.5^{bcde}	4.0^{abcd}	3.5^{ab}
T_{18}	3.0^{cde}	3.0^{b}	3.0^{bc}	3.3^{ab}	3.3^{a}	3.3^{ab}	4.0^{abc}	3.8^{abcd}	4.0^{abcd}	3.5^{ab}
T_{19}	5.5^{a}	3.8^{ab}	3.8^{ab}	3.5^{a}	3.3^{a}	3.0^{ab}	3.3^{bcde}	4.0^{abc}	4.3^{abcd}	3.3^{b}
T_{20}	3.0^{cde}	3.8^{ab}	3.6^{ab}	3.8^{a}	3.3^{a}	3.0^{ab}	3.9^{abcd}	3.8^{abcd}	4.5^{abc}	4.0^{ab}
$T_{0(1)}$	3.3^{bcde}	3.0^{b}	3.3^{bc}	3.3^{ab}	2.8^{a}	2.5^{b}	2.6^{e}	3.3^{cdef}	3.3^{d}	3.3^{b}
$T_{0(2)}$	3.5^{bcd}	3.5^{ab}	3.5^{abc}	3.5^{a}	3.0^{a}	3.3^{ab}	3.3^{bcde}	3.3^{cdef}	3.3^{d}	3.5^{ab}

Grouping was done by Duncan's Multiple Range Test

paclobutrazol 500 ppm (2.5 days). All the treatments were found to be on par with regard to the time taken for opening of a floret during January and February.

Significantly more time for floret opening was recorded by CCC 1000 ppm (4.5 days) compared to both the controls, during March, while minimum time was recorded for water sprayed control (2.6 days). During April, maximum delay in floret opening was recorded for BA 200 ppm + 1% urea (4.5 days) and minimum for paclobutrazol 500 ppm with and without 1% urea (2.8 days).

Difference among the treatments was significant during May, and the two controls recorded quickest floret opening (3.3 days). Delay was maximum (5 days) for BA 200 ppm. None of the treatments differed significantly from non-sprayed controls during June, but all GA containing treatments except GA 200 ppm + 1% urea and BA 200 ppm + 1% urea (4.3 days each) differed significantly compared to non-sprayed control (3.3 days).

4.2.2 Time required for the complete opening of florets in a spike

In this case also, there was significant difference with respect to field treatments, different months and their interaction.

Effect of field treatments

Maximum time for complete floret opening in a spike was recorded for GA 200 ppm (22.5 days) on an average and minimum for paclobutrazol 250 ppm + 1% urea (12.7 days) (Table 11). In general GA, BA and CCC containing treatments recorded more time for complete opening of florets in a spike.

Effect of months

The data showed that (Table 11), time taken for the complete floret opening in a spike was maximum during December (24.6 days) followed by February (23.3 days) and minimum during June (14.6 days).

Interaction effect

Interaction was found to be significant (Table 10) and the maximum time for complete opening of florets in a spike was recorded for GA 200 ppm (39.3 days) during February, and the minimum for paclobutrazol 250 ppm treatment during the month of April (4.5 days).

During September, October and November BA 200 ppm + 1% urea differed significantly from all other treatments and it recorded the maximum time for complete floret opening. During September, CCC 500 ppm showed the least time for complete floret opening. Minimum time during October was for paclobutrazol 500 ppm treatment (11.9 days) while it was for paclobutrazol 250 ppm + 1% urea (13.3 days) during November. None except GA 100 ppm + 1% urea (31.3 days) and GA 200 ppm + 1% urea (30.5 days) showed significant difference from both the controls during December. During January all the treatmens were found to be on par with controls; while CCC 1000 ppm (29.6 days) showed a significant difference. During February GA 200 ppm took maximum time for complete floret opening (39.3 days) and has a significant difference, while all others were on par with controls. During March maximum time was recorded for $ZnSO_4$ 0.25% treatment (26 days), but difference was not significant compared to controls.

Table 10. Effect of bioregulators on the time required for the complete opening of florets in a spike of crossandra (in days) taken at monthly intervals

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	17.5^{b}	17.8^{bc}	18.8^{bcd}	28.4^{abc}	25.3^{abcd}	27.5^{b}	25.5^{ab}	19.8^{cde}	17.8^{de}	17.0^{abcd}
T_2	16.8^{bc}	19.8^{ab}	21.8^{bc}	31.3^{a}	21.1^{abcde}	27.0^{b}	21.5^{abcde}	18.0^{def}	17.0^{def}	14.0^{bcdefg}
T_3	16.5^{bcd}	15.9^{cdefg}	19.0^{bcd}	25.3^{abcde}	26.5^{abc}	39.3^{a}	24.0^{abc}	25.3^{ab}	22.3^{b}	17.0^{abcd}
T_4	12.8^{fgh}	13.4^{gh}	20.8^{bc}	30.5^{ab}	23.5^{abcde}	25.8^{b}	19.0^{defg}	20.0^{cde}	26.0^{a}	12.5^{efgh}
T_5	16.8^{bc}	17.6^{bcd}	19.0^{bcd}	27.3^{abcde}	28.7^{ab}	19.8^{b}	24.0^{abc}	17.8^{defg}	17.0^{def}	16.0^{abcdef}
T_6	14.3^{cdefg}	15.9^{cdefg}	19.8^{bc}	28.5^{abc}	23.3^{abcde}	20.0^{b}	23.0^{abcd}	12.3^{hi}	21.0^{bc}	13.0^{defgh}
T_7	17.5^{b}	17.4^{bcd}	20.8^{bc}	23.5^{bcdef}	16.8^{cde}	19.0^{b}	21.0^{bcdef}	15.8^{fg}	14.6^{fg}	17.5^{abc}
T_8	20.5^{a}	22.7^{a}	27.8^{a}	21.0^{def}	19.0^{bcde}	21.3^{b}	22.5^{abcd}	26.3^{a}	21.0^{bc}	17.0^{abcd}
T_9	15.0^{bcdef}	11.9^{h}	16.3^{cd}	20.0^{ef}	15.5^{de}	22.3^{b}	20.0^{cdef}	14.5^{gh}	10.0^{hi}	18.0^{ab}
T_{10}	15.5^{bcde}	15.1^{cdefg}	17.5^{bcd}	22.5^{cdef}	17.8^{cde}	18.5^{b}	17.3^{efg}	20.0^{cde}	16.0^{ef}	16.5^{abcde}
T_{11}	12.5^{fgh}	13.3^{gh}	17.0^{cd}	16.5^{f}	14.5^{e}	23.0^{b}	16.5^{fg}	4.5^{j}	8.0^{ij}	12.0^{fgh}
T_{12}	11.8^{gh}	13.3^{gh}	13.3^{b}	16.5^{f}	14.5^{e}	19.5^{b}	10.8^{h}	10.5^{i}	5.0^{k}	10.0^{gh}
T_{13}	11.5^{h}	14.0^{fgh}	23.3^{ab}	26.6^{abcde}	21.0^{abcde}	27.0^{b}	21.8^{abcde}	17.0^{efg}	20.0^{bcd}	9.0^{h}
T_{14}	15.5^{bcde}	17.1^{bcde}	20.0^{bc}	25.4^{abcde}	24.8^{abcd}	24.8^{b}	22.3^{abcd}	16.8^{efg}	18.5^{cde}	13.0^{defgh}
T_{15}	15.8^{bcde}	15.9^{cdefg}	21.8^{bc}	27.7^{abcd}	29.6^{a}	26.3^{b}	23.8^{abcd}	16.8^{efg}	16.5^{ef}	16.0^{abcdef}
T_{16}	16.4^{bcde}	16.9^{bcdef}	22.0^{abc}	23.5^{bcdef}	20.0^{abcde}	22.0^{b}	22.8^{abcd}	20.5^{cd}	13.0^{g}	16.0^{abcdef}
T_{17}	13.8^{efgh}	13.3^{gh}	19.3^{bc}	23.4^{bcdef}	16.5^{de}	21.0^{b}	26.0^{a}	19.8^{cde}	11.8^{gh}	14.0^{bcdefg}
T_{18}	14.0^{defgh}	16.3^{cdefg}	18.0^{bcd}	26.7^{abcde}	25.0^{abcd}	18.8^{b}	19.0^{defg}	10.8^{i}	10.0^{hi}	12.0^{fgh}
T_{19}	16.3^{bcde}	13.6^{gh}	19.0^{bcd}	26.4^{abcde}	23.5^{abcde}	22.5^{b}	22.0^{abcde}	14.5^{gh}	12.3^{gh}	19.0^{a}
T_{20}	12.4^{fgh}	14.8^{defgh}	19.5^{bc}	26.3^{abcde}	17.3^{cde}	23.8^{b}	14.8^{gh}	14.8^{fgh}	7.0^{jk}	10.0^{gh}
$T_{0(1)}$	14.3^{cdefgh}	14.9^{cdefgh}	21.0^{bc}	20.3^{def}	20.0^{abcde}	20.8^{b}	24.3^{abcdef}	23.0^{abc}	19.0^{cde}	13.0^{cdefg}
$T_{0(2)}$	15.8^{bcde}	14.4^{efgh}	21.8^{bc}	22.8^{cdef}	19.5^{bcde}	22.0^{b}	22.5^{abcd}	23.0^{abc}	18.5^{cde}	17.0^{abcd}

Grouping was done by Duncan's Multiple Range Test

Table 11. Monthly variation in the flower development of crossandra (in days)

Months	Time taken for first floret appearance	Time taken for the opening of a floret	Time taken for complete opening of florets in a spike
September	19.0[a]	3.4[e]	15.1[d]
October	18.1[b]	3.5[d]	15.7[d]
November	15.9[d]	3.4[e]	19.9[b]
December	17.5[c]	3.3[f]	24.6[a]
January	16.2[d]	3.0[g]	21.2[b]
February	15.0[e]	3.0[g]	23.3[a]
March	14.8[e]	3.6[c]	20.6[b]
April	15.4[f]	3.5[d]	17.1[c]
May	12.7[g]	4.4[a]	15.3[d]
June	15.0[e]	3.8[b]	14.6[d]

Grouping was done by Duncans's Multiple Range Test

Table 12. Effect of different bioregulators on flower development characters of crossandra (in days)

Treatments	Time taken for first floret appearance	Time taken for the opening of a floret	Time taken for completing opening of florets in a spike
T_1	14.7^{hijk}	3.7^{de}	21.5^{ab}
T_2	12.8^{n}	3.9^{a}	21.0^{abcd}
T_3	13.7^{m}	3.7^{e}	22.5^{a}
T_4	16.7^{e}	3.4^{g}	20.5^{bcde}
T_5	15.2^{ghi}	3.8^{bc}	20.0^{bcdef}
T_6	13.0^{n}	3.7^{cde}	19.0^{defghi}
T_7	14.0^{klm}	3.6^{de}	18.3^{fghij}
T_8	14.5^{ijkl}	3.9^{a}	21.7^{ab}
T_9	16.2^{ef}	3.0^{k}	16.6^{jk}
T_{10}	13.8^{lm}	2.8^{l}	17.7^{ghijk}
T_{11}	19.6^{b}	3.1^{j}	13.9^{l}
T_{12}	20.6^{a}	3.2^{hi}	12.7^{l}
T_{13}	14.9^{ghi}	3.2^{ij}	19.1^{cdefgh}
T_{14}	18.4^{c}	3.8^{cd}	19.8^{bcdefg}
T_{15}	17.4^{d}	3.7^{cde}	21.1^{abc}
T_{16}	15.7^{fg}	3.7^{de}	19.2^{cdefgh}
T_{17}	14.1^{jklm}	3.3^{hi}	17.6^{hijk}
T_{18}	17.4^{d}	3.4^{gh}	17.0^{ijk}
T_{19}	15.0^{ghi}	3.7^{de}	18.6^{efghij}
T_{20}	14.8^{hij}	3.6^{f}	15.9^{k}
$T_{0(1)}$	15.4^{fgh}	2.9^{l}	18.9^{defghi}
$T_{0(2)}$	16.0^{ef}	3.3^{ghi}	$19.7^{bcdefgh}$

Grouping was done by Duncan's Multiple Range Test

Time required for complete opening of florets in a spike was more for BA 200 ppm + 1% urea (26.3 days) and GA 200 ppm (25.3 days) during April and minimum time was recorded for paclobutrazol 250 ppm (4.5 days). GA 200 ppm+ 1% urea recorded maximum time for complete floret opening (26 days) during May and minimum time was recorded for paclobutrazol 250 ppm + 1% urea (5 days). During June, $ZnSO_4$ 0.5% recorded maximum time (19 days) while, CCC 500 ppm showed minimum time (9 days).

4.2.5 Number of florets in a spike

Number of florets in a spike showed almost similar variations as the above character and the effect of field treatments, months and their interaction were found to be significant.

Effect of field treatments

Difference among the field treatments were significant (Table 18). On an average maximum number of florets was recorded for GA 200 ppm treatment (45.4) and minimum for paclobutrazol 250 ppm + 1% urea treatment (25.1).

Effect of months

Among the ten months period maximum number of florets on an average was recorded during the month of December (48.6) and minimum during June (29.1) (Table 17).

Interaction effect

Interaction effect was significant (Table 13).

Table 13. Effect of bioregulators on the total number of florets produced in a spike of crossandra during different months

Treat-ments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	36.0^{ab}	35.7^{abc}	37.5^{ab}	56.8^{ab}	50.5^{a}	55.0^{ab}	51.0^{a}	39.5^{cde}	38.5^{bcde}	34.0^{abc}
T_2	33.0^{abcde}	39.8^{ab}	43.5^{ab}	62.7^{a}	48.3^{a}	54.0^{ab}	43.0^{bcd}	37.0^{cdef}	36.0^{cde}	26.0^{abc}
T_3	34.0^{abcd}	31.8^{bc}	38.0^{ab}	50.5^{ab}	53.0^{a}	78.5^{a}	$43.5P^{bcd}$	51.5^{ab}	44.5^{ab}	35.0^{ab}
T_4	25.8^{bcde}	26.8^{c}	41.5^{ab}	61.0^{a}	47.0^{a}	51.5^{ab}	38.0^{de}	41.0^{cd}	50.0^{a}	25.0^{abc}
T_5	33.5^{abcd}	35.3^{abc}	38.0^{ab}	54.5^{ab}	57.3^{a}	39.5^{b}	45.0^{abcd}	35.5^{cdef}	33.5^{ef}	32.0^{abc}
T_6	28.0^{bcde}	31.8^{bc}	39.5^{ab}	47.0^{ab}	46.5^{a}	40.5^{b}	42.0^{bcd}	24.5^{g}	42.0^{bc}	26.0^{abc}
T_7	35.0^{abc}	34.9^{abc}	41.5^{ab}	47.1^{ab}	33.5^{a}	38.0^{b}	42.0^{bcd}	31.5^{defg}	28.5^{fg}	35.0^{ab}
T_8	39.5^{a}	45.4^{a}	55.5^{a}	42.0^{ab}	38.0^{a}	42.5^{ab}	43.0^{bcd}	52.5^{a}	42.0^{bc}	34.0^{abc}
T_9	29.0^{abcde}	23.9^{c}	32.5^{ab}	40.0^{ab}	31.0^{a}	44.5^{ab}	39.0^{de}	29.0^{efg}	20.0^{hi}	36.0^{ab}
T_{10}	26.6^{bcde}	30.1^{bc}	35.0^{ab}	45.0^{ab}	35.5^{a}	37.0^{b}	33.5^{ef}	40.0^{cde}	29.0^{fg}	23.0^{abc}
T_{11}	23.6^{de}	26.6^{c}	34.0^{ab}	33.0^{b}	29.0^{a}	46.0^{ab}	34.0^{ef}	9.0^{h}	18.0^{ij}	20.0^{bc}
T_{12}	22.3^{e}	26.5^{c}	26.5^{b}	33.0^{b}	29.0^{a}	39.0^{b}	21.5^{g}	27.0^{fg}	9.0^{k}	18.0^{c}
T_{13}	27.0^{bcde}	28.0^{bc}	46.5^{ab}	53.3^{ab}	42.0^{a}	54.0^{ab}	43.5^{bcd}	38.0^{cdef}	40.0^{bcd}	26.0^{abc}
T_{14}	33.1^{abcde}	34.3^{abc}	40.0^{ab}	50.8^{ab}	49.5^{a}	49.5^{ab}	44.5^{abcd}	35.5^{cdef}	39.0^{bcde}	32.0^{abc}
T_{15}	32.0^{abcde}	31.8^{bc}	43.5^{ab}	55.3^{ab}	49.3^{a}	52.5^{ab}	46.5^{abc}	36.5^{cdef}	35.0^{de}	32.0^{abc}
T_{16}	31.5^{abcde}	33.8^{abc}	44.0^{ab}	47.1^{ab}	40.0^{a}	44.0^{ab}	48.5^{ab}	37.0^{cdef}	26.0^{gh}	29.0^{abc}
T_{17}	25.3^{bcde}	26.5^{c}	38.5^{ab}	46.8^{ab}	33.0^{a}	42.0^{ab}	51.0^{a}	29.5^{efg}	23.5^{ghi}	24.0^{abc}
T_{18}	31.1^{abcde}	32.5^{bc}	36.0^{ab}	53.1^{ab}	50.0^{a}	37.5^{ab}	38.0^{de}	23.5^{g}	20.0^{hi}	32.0^{abc}
T_{19}	31.5^{abcde}	27.3^{c}	38.0^{ab}	52.5^{ab}	47.0^{a}	$45.^{ab}$	40.0^{cde}	31.0^{defg}	24.5^{gh}	38.0^{a}
T_{20}	24.9^{cde}	29.5^{bc}	39.0^{ab}	52.6^{ab}	34.5^{a}	47.0^{ab}	29.5^{f}	38.5^{cde}	13.5^{jk}	21.0^{bc}
$T_{0(1)}$	29.0^{abcde}	29.8^{bc}	42.0^{ab}	40.6^{ab}	40.0^{a}	41.5^{ab}	41.5^{bcd}	42.0^{bcd}	38.0^{cde}	28.0^{abc}
$T_{0(2)}$	31.5^{abcde}	28.8^{bc}	43.5^{ab}	45.6^{ab}	39.0^{a}	44.0^{ab}	39.0^{de}	46.0^{abc}	39.0^{bcde}	34.0^{abc}

Grouping was done Duncan's Multiple Range Test

During September maximum floret production/spike was recorded for BA 200 ppm + 1% urea (39.5) and minimum by paclobutrazol 250 ppm + 1% urea (22.3). Lowest floret production was always recorded by one or other paclobutrazol treatments. During October, November and April also BA 200 ppm + 1% urea produced maximum number of florets (45.4, 55.5 and 52.5 respectively), while GA 200 ppm recorded maximum floret production during February (78.5). Maximum production during December was for GA 100 ppm + 1% urea (61.0), during January for BA 100 ppm (57.3), during March for GA 100 ppm and $ZnSO_4$ 0.25% (51), during May for GA 200 ppm + 1% urea (50) and during June for $ZnSO_4$ 0.5% (38).

4.2.6 Number of spikes per plant

Effect of treatments

Effect of treatments was found to be significant in the case of the number of spikes per plant. On an average, maximum number of spikes was recorded in treatment with BA 200 ppm + 1% urea (15.2) followed by GA 200 ppm (12.6) but both differed significantly. Paclobutrazol treatments produced the minimum number of spikes and the lowest spike production was recorded for paclobutrazol 250 ppm treatment (3.0) (Table 18).

Effect of months

When we take the effect of months on an average spikes per plant were maximum during June (11.9) and it differed significantly from all others. Minimum number of spikes per plant was recorded (3.6) during the month of September (Table 17).

Table 14. Number of spikes per plant in crossandra at monthly intervals as influenced by different bioregulators

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	5.1^{bcd}	10.0^{abc}	9.6^{bcde}	14.1^{bc}	13.0^{abc}	13.6^{abcd}	10.0^{ab}	6.9^{abc}	9.0^{abcd}	11.7^{cdef}
T_2	6.1^{b}	7.1^{bcde}	6.3^{cde}	7.1^{d}	7.0^{bcd}	7.8^{defgh}	7.1^{bcde}	4.3^{bc}	3.7^{cd}	19.0^{b}
T_3	2.6^{ef}	10.9^{ab}	10.8^{bc}	13.4^{bcd}	11.4^{abcd}	15.8^{ab}	13.1^{a}	9.5^{a}	12.3^{a}	26.0^{a}
T_4	5.1^{bcd}	6.6^{bcde}	6.9^{cde}	8.3^{cde}	14.3^{ab}	8.9^{cdefgh}	5.4^{cdefgh}	5.3^{abc}	9.9^{abcd}	11.9^{cde}
T_5	5.5^{bcd}	12.8^{a}	15.5^{ab}	15.4^{b}	10.0^{bcd}	14.5^{abc}	9.9^{ab}	6.2^{abc}	12.0^{ab}	15.3^{bcd}
T_6	1.6^{f}	5.5^{bcde}	7.4^{cde}	8.0^{cde}	8.3^{bcd}	7.1^{efgh}	4.5^{defgh}	3.0^{c}	3.1^{d}	8.00^{efg}
T_7	2.0^{f}	6.0^{bcde}	5.9^{cde}	8.0^{cde}	10.8^{bcd}	11.5^{bcde}	9.0^{bc}	7.0^{abc}	10.6^{abcd}	16.4^{bc}
T_8	8.3^{a}	13.3^{a}	17.8^{a}	22.5^{a}	19.9^{a}	18.1^{a}	13.0^{a}	8.5^{ab}	11.8^{abc}	19.0^{b}
T_9	4.1^{cde}	5.9^{bcde}	8.3^{cde}	5.1^{e}	5.1^{bcd}	5.9^{efgh}	2.5^{gh}	2.5^{c}	4.6^{abcd}	9.5^{ef}
T_{10}	5.9^{bc}	6.0^{bcde}	4.9^{cde}	4.5^{e}	5.3^{bcd}	3.6^{h}	2.3^{h}	2.5^{c}	4.0^{bcd}	6.5^{fg}
T_{11}	1.8^{f}	2.4^{e}	3.4^{e}	4.5^{e}	2.5^{d}	4.6^{fgh}	2.3^{h}	2.0^{c}	2.8^{d}	3.5^{g}
T_{12}	3.1^{ef}	3.1^{de}	3.9^{de}	4.4^{e}	4.0^{cd}	3.9^{gh}	2.8^{fgh}	2.1^{c}	2.8^{d}	3.5^{g}
T_{13}	4.0^{de}	8.4^{abcd}	10.3^{bcd}	10.6^{bcde}	14.4^{ab}	$9.6^{bcdefgh}$	8.3^{bcd}	4.6^{abcd}	8.5^{abcd}	12.8^{cde}
T_{14}	2.6^{ef}	6.0^{bcde}	7.1^{cde}	7.6^{de}	7.3^{bcd}	7.0^{efgh}	5.1^{cdefgh}	3.3^{c}	5.0^{abcd}	10.0^{ef}
T_{15}	2.5^{ef}	6.5^{bcde}	5.9^{cde}	9.0^{cde}	10.4^{bcd}	9.4^{cdefgh}	4.8^{defgh}	4.3^{bc}	5.9^{abcd}	10.0^{ef}
T_{16}	3.3^{ef}	7.5^{bcde}	9.1^{cde}	9.9^{bcde}	10.1^{bcd}	12.3^{abcde}	10.1^{ab}	6.1^{abc}	9.9^{abcd}	17.9^{b}
T_{17}	2.0^{f}	5.4^{bcde}	4.5^{cde}	8.0^{cde}	6.0^{bcd}	7.1^{efgh}	5.8^{cdefgh}	2.9^{c}	9.0^{abcd}	10.0^{ef}
T_{18}	3.1^{ef}	5.9^{bcde}	6.5^{cde}	7.6^{de}	5.3^{bcd}	7.5^{defgh}	3.8^{efgh}	3.1^{c}	6.0^{abcd}	8.0^{efg}
T_{19}	2.8^{ef}	7.4^{bcde}	6.9^{cde}	7.6^{de}	7.0^{bcd}	10.1^{bcdefg}	8.0^{bcd}	3.5^{bc}	6.5^{abcd}	12.0^{cde}
T_{20}	3.0^{ef}	6.5^{bcde}	7.1^{cde}	8.8^{cde}	6.3^{bcd}	8.0^{defgh}	4.8^{defgh}	3.5^{bc}	6.5^{abcd}	9.5^{ef}
$T_{0(1)}$	2.5^{ef}	7.1^{bcde}	8.5^{cde}	9.9^{bcde}	7.8^{bcd}	11.3^{bcde}	6.4^{bcdefg}	5.4^{abc}	9.1^{abcd}	10.0^{ef}
$T_{0(2)}$	1.6^{f}	4.9^{cde}	6.5^{cde}	8.4^{cde}	9.3^{bcd}	10.9^{bcdef}	6.5^{bcdef}	8.4^{ab}	9.0^{abcd}	10.5^{def}

Grouping was done by Duncan's Multiple Range Test

Interaction effect

Interaction effect of months and treatments was significant. Maximum number of spikes per plant was recorded for GA 200 ppm treatment during the month of June (26) and minimum for non-sprayed control (1.6) during the month of September (Table 14).

During September, maximum spike production was noticed for BA 200 ppm + 1% urea (8.3) and minimum for water sprayed control (1.6) and the former showed significant difference from all other treatments. BA 200 ppm + 1% urea continued to be the best treatment with regard to the number of spikes per plant till February, but latter, till June GA 200 ppm produced maximum number of spikes per plant. During most of the months paclobutrazol 250 ppm with and without 1% urea recorded minimum number of spikes (3.1 and 2.4 during October, 3.9 and 3.4 during November, 4.0 and 2.5 during January, 2.1 and 2 during April, 2.8 each during May and 3.5 each during June). All the paclobutrazol treatments recorded very low spike production throughout the study period. Compared with controls the difference was insignificant for most of the treatments throughout the study period.

4.2.7 Number of florets per plant

Significant variation in the floret yield was noticed among treatments (Table 15). During September BA 200 ppm + 1% urea recorded maximum floret yield/plant (192.8) followed by GA 200 ppm (156.5) which differed significantly from each other and all other treatments, while minimum floret yield was recorded for BA 100 ppm + 1% urea (41.5). During October no significant difference was

Table 15. Effect of bioregulators on the total number of florets per plant in crossandra at monthly intervals

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	117.0^{c}	202.5^{ab}	254.3^{abcd}	289.1^{bcde}	576.4^{a}	424.8^{ab}	354.8^{bcde}	261.5^{bc}	156.0^{cde}	309.5^{bc}
T_2	115.5^{c}	218.6^{ab}	114.6^{bcdef}	290.2^{bcde}	168.6^{bc}	139.0^{cde}	272.5^{cdefg}	235.0^{bcd}	56.0^{e}	49.3^{fg}
T_3	156.5^{b}	106.5^{ab}	337.3^{a}	150.3^{cde}	342.3^{abc}	144.6^{cde}	655.1^{a}	109.9^{def}	643.4^{a}	287.0^{bc}
T_4	103.0^{c}	141.8^{ab}	81.8^{cdef}	359.5^{abcd}	182.3^{bc}	361.3^{abcd}	318.3^{cdef}	123.5^{def}	401.5^{b}	51.0^{fg}
T_5	100.5^{c}	202.1^{ab}	266.0^{abc}	491.6^{ab}	483.1^{ab}	277.5^{bcde}	517.5^{ab}	71.8^{f}	92.1^{e}	341.0^{b}
T_6	41.5^{e}	59.1^{b}	172.6^{abcdef}	182.8^{cde}	197.8^{bc}	169.3^{bcde}	623.5^{a}	122.1^{def}	346.5^{b}	94.0^{efg}
T_7	92.3^{cd}	86.8^{ab}	205.9^{abcde}	102.2^{e}	218.4^{bc}	88.6^{de}	187.0^{efgh}	177.6^{cde}	355.9^{b}	148.3^{def}
T_8	192.8^{a}	346.0^{a}	299.1^{ab}	549.5^{a}	418.0^{abc}	365.0^{abc}	21.5^{h}	712.5^{a}	168.0^{cde}	467.5^{a}
T_9	71.0^{de}	134.5^{ab}	85.5^{cdef}	248.0^{cde}	99.3^{c}	220.9^{bcde}	35.3^{h}	84.8^{ef}	60.0^{e}	94.8^{efg}
T_{10}	99.8^{c}	169.7^{ab}	74.0^{def}	172.0^{cde}	135.3^{bc}	182.3^{bcde}	40.8^{h}	80.0^{ef}	65.3^{e}	66.8^{fg}
T_{11}	63.5^{e}	54.1^{b}	37.5^{ef}	107.3^{e}	72.8^{c}	78.5^{e}	131.8^{fgh}	4.5^{f}	57.5^{e}	44.8^{fg}
T_{12}	50.0^{e}	80.5^{ab}	13.3^{f}	147.0^{cde}	73.8^{c}	150.8^{bcde}	22.9^{h}	12.0	84.3^{e}	9.0^{g}
T_{13}	58.3^{e}	121.5^{ab}	187.8^{abcdef}	392.4^{abc}	315.6^{abc}	600.3^{a}	21.8^{h}	331.0^{b}	20.0^{e}	232.0^{bcd}
T_{14}	58.3^{e}	103.4^{ab}	160.5^{abcdef}	214.8^{cde}	174.0^{bc}	188.8^{bcde}	183.8^{efgh}	72.3^{ef}	116.8^{e}	204.8^{cde}
T_{15}	56.3^{e}	96.0^{ab}	206.4^{abcde}	130.5^{de}	260.1^{abc}	156.3^{bcde}	341.8^{bcde}	18.3^{f}	311.5^{bcd}	84.0^{efg}
T_{16}	71.0^{de}	117.9^{ab}	219.0^{abcde}	224.6^{cde}	154.0^{bc}	225.5^{bcde}	446.1^{bc}	75.3^{ef}	113.8^{e}	203.0^{cde}
T_{17}	49.5^{e}	64.4^{ab}	151.4^{abcdef}	46.8^{e}	232.5^{abc}	263.0^{bcde}	83.3^{gh}	142.3^{cdef}	20.4^{e}	218.3^{cd}
T_{18}	67.3^{de}	120.0^{ab}	154.9^{abcdef}	175.9^{cde}	157.5^{bc}	80.3^{e}	232.8^{defg}	11.8^{f}	137.5^{de}	16.0^{g}
T_{19}	62.0^{e}	101.8^{ab}	175.1^{abcdef}	199.5^{cde}	167.5^{bc}	147.8^{cde}	315.3^{cdef}	39.5^{ef}	151.4^{cde}	84.0^{efg}
T_{20}	52.8^{e}	87.2^{ab}	137.5^{bcdef}	247.8^{cde}	149.6^{bc}	166.3^{bcde}	162.9^{efgh}	25.5^{f}	88.4^{e}	31.8^{fg}
$T_{0(1)}$	58.0^{e}	86.0^{ab}	193.5^{abcdef}	191.0^{cde}	178.0^{bc}	93.9^{cde}	394.6^{bcd}	21.0^{f}	365.9^{b}	35.0^{fg}
$T_{0(2)}$	63.0^{e}	66.0^{ab}	95.6^{cdef}	239.3^{cde}	101.8^{c}	173.3^{bcde}	339.0^{bcde}	74.8^{ef}	326.3^{bc}	53.8^{fg}

Grouping was done by Duncan's Multiple Range Test

observed from control for any treatment, but BA 200 ppm + 1% urea (maximum) recorded significantly maximum floret yield (346/plant) compared to paclobutrazol 250 ppm treatment (54.1); which was minimum during that period. During November GA 200 ppm recorded maximum floret yield/plant (337.3), followed by BA 200 ppm + 1% urea (299.1), and the minimum by paclobutrazol 250 ppm + 1% urea (13.3). During December maximum yield was for BA 200 ppm + 1% urea (549.5) and during January for GA 100 ppm (576.4) while minimum floret yield was for $ZnSO_4$ 0.25% (46.8) and paclobutrazol 250 ppm (72.8), during the two months and the former differed significantly from controls.

During February CCC 500 ppm recorded maximum number of florets per plant (600.3) and differed significantly from control and minimum was for paclobutrazol 250 ppm (78.5). GA 200 ppm and BA 100 ppm + 1% urea recorded maximum number of florets per plant during March (655.1 and 623.5 respectively). But by April BA 200 ppm + 1% urea recorded maximum and significantly higher yield from all other treatments (712.5), followed by CCC 500 ppm (331), while during this period minimum was for paclobutrazol 250 ppm (4.5). Maximum floret production/plant during May was for GA 200 ppm (643.4) which differed significantly from all othet treatments and minimum was recorded for CCC 500 ppm (20), which was significantly lower than both the controls. BA 200 ppm + 1% urea yielded best during June also (467.5 florets per plant) which was significantly higher than all other treatments followed by BA 100 ppm (34.1 florets per plant); while the minimum number of florets was recorded by the treatment paclobutrazol 250 ppm + 1% urea (9.0), but the difference was not significant compared to both the controls.

4.2.8 Number of spikes produced in a month

In the case of number of spikes produced in a month, significant effect was found for field treatments, months and their interaction.

Effect of field treatments

In the case of field treatments, maximum number of spikes produced/month was recorded for BA 200 ppm + 1% urea treatment (8.8) on an average and it differed significantly from all others except GA 200 ppm (7.7). Paclobutrazol treatments recorded low monthly spike production, and the minimum was recorded for paclobutrazol 250 ppm treatment (1.9) on an average (Table 18).

Effect of months

Maximum spike production was noticed during the month of June (10.0) on an average, which differed significantly from all others. Minimum spike production was recorded during March (2.8). Variation during different months on an average for all treatments is presented in Table 17.

Interaction effect

Interaction effect was found to be significant with regard to the number of spikes produced in a month. Maximum number of spikes were produced by the plants treated with GA 200 ppm during the month of June (18.4) and production was nil for certain treatments during certain months (Table 16).

Maximum number of spikes were produced by BA 200 ppm + 1% urea during September (8.3) and minimum by non-sprayed control (1.6), while during

Table 16. Number of spikes produced per month in crossandra as influenced by bioregulator treatments

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	5.1^{bc}	6.5^{ab}	4.6^{bcdef}	11.0^{a}	7.3^{abc}	6.5^{defg}	6.1^{bc}	3.6^{defg}	8.5^{bc}	11.7^{cdefg}
T_2	6.1^{b}	2.1^{cdef}	4.1^{cdef}	3.0^{c}	2.0^{def}	5.8^{defg}	5.9^{bc}	1.0^{g}	1.7^{fg}	17.5^{ab}
T_3	2.6^{de}	8.4^{a}	2.4^{def}	5.8^{abc}	4.2^{bcdef}	14.6^{a}	1.6^{f}	14.0^{a}	7.6^{bc}	18.4^{a}
T_4	5.1^{bc}	1.5^{def}	5.4^{bcde}	3.4^{c}	6.4^{abcd}	7.9^{cde}	2.50^{def}	7.6^{bcd}	1.8^{fg}	$10.4^{cdefghi}$
T_5	5.5^{bc}	6.5^{ab}	8.5^{b}	8.0^{abc}	6.4^{abcd}	10.9^{bc}	0.0^{f}	2.3^{efg}	10.3^{ab}	13.3^{cde}
T_6	1.6^{e}	3.9^{bcde}	3.5^{cdef}	4.0^{bc}	3.8^{bcdef}	14.4^{ab}	4.5^{cde}	7.8^{bcd}	3.1^{efg}	8.0^{ghij}
T_7	2.0^{e}	4.0^{bcd}	1.8^{ef}	5.4^{abc}	1.9^{def}	4.0^{fgh}	5.0^{cd}	12.0^{ab}	3.8^{def}	14.2^{bc}
T_8	8.3^{a}	5.0^{bc}	13.0^{a}	10.3^{ab}	8.3^{ab}	6.0^{defg}	13.0^{a}	3.5^{defg}	13.3^{a}	13.8^{bcd}
T_9	4.1^{cd}	2.1^{cdef}	6.1^{bcd}	2.8^{c}	4.5^{bcdef}	0.4^{ij}	2.5^{def}	2.5^{efg}	2.1^{fg}	7.4^{hijk}
T_{10}	5.9^{b}	1.6^{def}	3.1^{cdef}	3.1^{c}	4.0^{bcdef}	0.8^{hij}	1.5^{f}	1.8^{fg}	2.5^{efg}	4.6^{jkl}
T_{11}	1.8^{e}	0.6^{ef}	2.8^{cdef}	2.0^{c}	1.3^{f}	3.4^{ghij}	0.0^{f}	2.8^{efg}	1.6^{fg}	3.1^{l}
T_{12}	3.1^{de}	0.0^{f}	3.9^{cdef}	2.3^{c}	3.5^{cdef}	0.6^{hij}	2.1^{ef}	8.6^{bc}	0.0^{g}	3.5^{kl}
T_{13}	4.0^{cd}	3.4^{bcde}	6.9^{bc}	7.1^{abc}	10.5^{a}	0.0^{j}	8.3^{b}	0.0^{g}	8.5^{bc}	11.3^{cdefgh}
T_{14}	2.6^{de}	3.4^{bcde}	3.8^{cdef}	3.0^{c}	3.4^{cdef}	3.6^{ghi}	1.5^{f}	2.5^{efg}	5.9^{cde}	7.1^{ijkl}
T_{15}	2.5^{de}	4.0^{bcde}	1.9^{def}	4.5^{abc}	2.5^{def}	6.9^{defg}	0.0^{f}	8.4^{bc}	2.1^{fg}	7.9^{ghij}
T_{16}	3.3^{de}	4.3^{bcd}	4.3^{bcdef}	3.0^{c}	4.6^{bcdef}	8.6^{cd}	1.5^{f}	3.9^{defg}	6.9^{bcde}	12.7^{cdef}
T_{17}	2.0^{e}	3.4^{bcde}	0.5^{f}	6.5^{abc}	6.0^{abcde}	1.1^{hij}	4.6^{cd}	0.4^{g}	8.6^{bc}	10.0^{defghi}
T_{18}	3.3^{de}	3.9^{bcde}	2.6^{cdef}	2.6^{c}	1.6^{ef}	5.6^{defg}	0.0^{f}	6.4^{cde}	0.0^{g}	8.0^{ghij}
T_{19}	2.8^{d}	4.1^{bcd}	3.3^{cdef}	3.5^{c}	2.8^{cdef}	7.5^{cdef}	0.8^{f}	5.6^{cdef}	1.6^{fg}	$10.6^{cdefghi}$
T_{20}	3.0^{de}	3.0^{cdef}	4.1^{cdef}	3.9^{bc}	3.0^{cdef}	5.0^{efg}	0.1^{f}	6.0^{cdef}	1.0^{fg}	8.5^{ghij}
$T_{0(1)}$	2.5^{de}	4.0^{bcd}	4.0^{cdef}	3.5^{c}	1.9^{def}	9.1^{cd}	0.0^{f}	9.1^{bc}	0.9^{fg}	9.1^{fghi}
$T_{0(2)}$	1.6^{e}	1.8^{cdef}	4.8^{bcdef}	2.1^{c}	3.6^{bcdef}	8.3^{cde}	1.1^{f}	7.9^{bcd}	1.2^{fg}	9.4^{efghi}

Grouping was done by Duncan's Multiple Range Test

Table 17. Monthly variation in the yield and floral characters of crossandra

Month	Total No. of florets in a spike	Spikes/plant	No. of spikes produced/month	Length of spike (cm)	Stalk length of spike (cm)
September	30.2^{d}	3.6^{e}	3.6^{de}	19.4^{c}	8.6^{e}
October	31.4^{d}	7.0^{d}	3.5^{de}	22.4^{b}	11.8^{b}
November	39.7^{b}	7.9^{cd}	4.3^{cd}	25.6^{a}	13.2^{a}
December	48.6^{a}	9.2^{b}	4.6^{cd}	24.7^{a}	10.2^{c}
January	41.9^{b}	8.9^{bc}	4.1^{d}	22.7^{b}	9.5^{d}
February	46.5^{a}	9.5^{b}	5.7^{b}	20.2^{c}	6.2^{f}
March	41.2^{b}	6.6^{d}	2.8^{e}	16.5^{d}	4.3^{h}
April	34.0^{c}	4.7^{e}	5.3^{bc}	12.6^{e}	2.8^{i}
May	31.0^{d}	7.3^{d}	4.2^{d}	11.8^{e}	2.1^{j}
June	29.1^{d}	11.9^{a}	10.0^{a}	15.7^{d}	5.5^{g}

Grouping was done by Duncan's Multiple Range Test

Table 18. Effect of bioregulators on yield and floral characters of crossandra as an average of 10 months

Treatment	Total No. of florets in a spike	Spikes/plant	No. of spikes produced/month	Length of spike (cm)	Stalk length of spike (cm)
T_1	43.1^{ab}	10.3^{cd}	7.1^{bc}	21.1^{cdefg}	8.7^{def}
T_2	41.7^{abc}	7.5^{fghij}	4.9^{defg}	21.2^{cdef}	8.4^{def}
T_3	45.4^{a}	12.6^{b}	7.7^{ab}	24.3^{b}	10.8^{b}
T_4	40.9^{bcde}	8.2^{efgh}	5.2^{def}	21.2^{cdef}	8.5^{def}
T_5	40.0^{bcdef}	11.6^{bc}	7.2^{bc}	21.6^{cd}	8.9^{cde}
T_6	36.8^{fgh}	5.7^{jkl}	5.5^{de}	19.7^{efghi}	9.1^{cd}
T_7	36.5^{fgh}	8.7^{defg}	5.4^{de}	22.8^{bc}	9.7^{c}
T_8	43.2^{ab}	15.2^{a}	8.8^{a}	28.0^{a}	14.1^{a}
T_9	33.1^{hi}	5.4^{kl}	3.5^{ghi}	10.8^{jk}	1.4^{i}
T_{10}	34.9^{ghi}	4.5^{lm}	2.9^{hij}	11.0^{j}	0.9^{i}
T_{11}	27.0^{j}	3.0^{m}	1.9^{j}	9.3^{kl}	1.0^{i}
T_{12}	25.1^{j}	3.4^{m}	2.8^{ij}	7.7^{l}	0.5^{i}
T_{13}	39.4^{bcdef}	9.1^{def}	6.0^{cd}	19.6^{fghi}	7.4^{gh}
T_{14}	40.3^{bcdef}	6.1^{ijkl}	3.7^{fghi}	21.8^{cd}	9.2^{cd}
T_{15}	41.2^{bcd}	6.9^{ghijk}	4.1^{efghi}	21.4^{cde}	8.0^{efgh}
T_{16}	38.0^{cdefg}	9.6^{de}	5.3^{de}	21.2^{cdef}	7.9^{fgh}
T_{17}	34.6^{ghi}	6.1^{ijkl}	4.3^{efgh}	19.2^{hi}	8.2^{defg}
T_{18}	35.0^{ghi}	5.7^{jkl}	3.4^{ghi}	18.7^{i}	7.1^{h}
T_{19}	37.0^{efg}	7.2^{fghijk}	4.2^{efghi}	19.3^{ghi}	7.7^{fgh}
T_{20}	31.8^{i}	6.4^{hijkl}	3.8^{fghi}	19.6^{fghi}	9.2^{cd}
$T_{0(1)}$	37.8^{defg}	7.8^{efghi}	4.4^{efgh}	20.5^{defgh}	7.8^{fgh}
$T_{0(2)}$	39.2^{cdef}	7.6^{fghij}	4.2^{efghi}	21.4^{cde}	8.7^{def}

Grouping was done by Duncan's Multiple Range Test

October GA 200 ppm produced maximum number of spikes (8.4) which differed significantly from both the controls (4 and 1.8). Spike production was nil for paclobutrazol 250 ppm + 1% urea during october. During November also, BA 200 ppm + 1% urea produced significantly higher number of spikes (13) and the minimum spike production during this month was for $ZnSO_4$ 0.25% (0.5).

During December GA 100 ppm and BA 200 ppm + 1% urea showed a significantly higher production of spike (11 and 10.3 respectively), while all others were on par with controls. Paclobutrazol (1000 ppm initial spray) 250 ppm produced minimum number of spikes (2) during December.

CCC 500 ppm produced maximum number of spikes during January (10.5) and during February, GA 200 ppm (14.6 produced maximum number of spikes, which was on par with BA 100 ppm + 1% urea (14.4) and spike production recorded was nil for CCC 500 ppm during this period. But during March BA 200 ppm + 1% urea and CCC 500 ppm produced maximum number of spikes (13 and 8.3 respectively) and BA 100 ppm, $ZnSO_4$ 0.25% + 1% urea, CCC 1000 ppm, water sprayed control and paclobutrazol 250 ppm treatments recorded nil production. GA 200 ppm recorded maximum spike production (14) and minimum by CCC 500 ppm during April. BA 200 ppm + 1% urea produced maximum number of spikes during May also (13.3) and it was significantly different from all other treatments except BA 100 ppm treatment (10.3). Production was nil for $ZnSO_4$ 0.25% + 1% urea and paclobutrazol 250 ppm + 1% urea during May.

Significant difference was noticed during June also, and GA 200 ppm produced maximum number of spikes (18.4) followed by GA 100 ppm + 1% urea (17.5) and both of them were on par. Low production of spike was noticed for

paclobutrazol treatments and the minimum production for paclobutrazol 250 ppm treatment (3.1).

4.2.9 Weight of 100 florets

Difference among the field treatments was significant statistically (Table 19). Compared to either or both of the control most of the treatments showed insignificant difference during September except GA 200 ppm, BA 100 ppm + 1% urea, BA 200 ppm and all paclobutrazol treatments, which recorded a significantly lower weight for 100 florets. Weight recorded was maximum for GA 200 ppm + 1% urea (4.8 g) during this period. During October, GA 100 ppm + 1% urea treatment recorded maximum weight of 100 florets (5.62 g), followed by GA 200 ppm (5.43 g) and the minimum was recorded for paclobutrazol 250 ppm treatment (3.89 g) GA 200 ppm recorded maximum weight of 100 florets during November (5.56 g) followed by GA 100 ppm + 1% urea (5.54 g) treatment and the minimum for paclobutrazol 250 ppm treatment (3.97 g).

Maximum weight was recorded for $ZnSO_4$ 0.5% + 1% urea treatment during December (4.88 g). All the paclobutrazol treatments except paclobutrazol 500 ppm showed significant reduction in the weight of 100 florets (4.04 to 3.84 g) compared to controls and most of the other treatments.

Most of the treatments differed significantly from control during the months of January, February and March. Maximum weight was recorded for GA 200 ppm treatment and GA 100 ppm. Minimum weight of 100 florets was recorded by paclobutrazol 250 ppm + 1% urea, preceeded by paclobutrazol 250 ppm during these months.

Table 19. Effect of bioregulator treatments on the weight of 100 florets (g) in crossandra at monthly intervals

Treat-ments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	4.51^{bcd}	5.11^{bcd}	5.36^{b}	4.78^{ab}	5.27^{ab}	6.06^{a}	5.16^{a}	5.10^{de}	5.30^{abcde}	6.55^{d}
T_2	4.65^{ab}	5.62^{a}	5.54^{a}	4.86^{a}	5.15^{bc}	5.58^{abc}	4.68^{cd}	5.66^{ab}	6.35^{a}	6.85^{a}
T_3	4.36^{d}	5.43^{ab}	5.56^{a}	4.52^{abcd}	5.33^{a}	6.02^{a}	5.12^{ab}	5.89^{a}	6.13^{abc}	6.75^{b}
T_4	4.80^{a}	4.95^{bcdef}	5.0^{cde}	4.78^{ab}	4.85^{efgh}	5.62^{abc}	4.67^{cd}	5.09^{def}	5.49^{abcde}	6.35^{f}
T_5	4.53^{bcd}	5.19^{abc}	5.13^{c}	4.54^{abcd}	4.59^{jk}	5.66^{ab}	4.53^{a}	5.63^{b}	6.19^{ab}	6.55^{d}
T_6	4.34^{de}	4.44^{ghi}	4.72^{ghi}	4.40^{abcd}	4.54^{k}	5.36^{abcde}	4.50^{d}	5.04^{def}	4.74^{defg}	6.45^{e}
T_7	4.15^{ef}	4.54^{fghi}	4.62^{ij}	4.28^{bcde}	4.72^{ghij}	5.10^{bcde}	4.52^{d}	5.37^{c}	6.07^{abc}	6.65^{c}
T_8	4.52^{bcd}	5.06^{bcde}	4.97^{cde}	4.18^{cde}	4.83^{fgh}	5.72^{ab}	4.86^{abcd}	5.21^{cd}	5.53^{abcde}	6.75^{b}
T_9	4.15^{ef}	4.43^{ghi}	4.51^{j}	4.47^{abcd}	4.60^{ijk}	4.66^{def}	4.68^{cd}	4.72^{ghi}	5.05^{abcdef}	6.09^{hi}
T_{10}	3.96^{f}	4.24^{hij}	4.78^{fghi}	3.84^{e}	4.74^{ghi}	5.04^{bcde}	4.80^{abcd}	4.28^{j}	3.77^{g}	6.25^{g}
T_{11}	4.10^{f}	3.89^{j}	3.97^{k}	4.04^{de}	3.94^{m}	3.88^{f}	3.91^{e}	3.97^{k}	3.85^{fg}	6.15^{h}
T_{12}	4.02^{f}	4.15^{ij}	4.07^{k}	3.89^{e}	3.86^{m}	4.49^{ef}	3.62^{e}	4.05^{jk}	4.23^{efg}	6.07^{i}
T_{13}	4.62^{abc}	4.60^{efghi}	4.97^{cde}	4.54^{abcde}	4.9^{def}	5.18^{abcde}	4.70^{bcd}	4.83^{fgh}	4.87^{cdefg}	6.35^{f}
T_{14}	4.55^{bcd}	4.84^{cdefg}	4.91^{def}	4.62^{abc}	4.86^{efg}	4.86^{bcde}	4.73^{bcd}	5.10^{def}	5.50^{abcde}	6.55^{b}
T_{15}	4.41^{cd}	4.16^{ij}	4.73^{ghi}	4.54^{abcd}	4.13^{l}	4.73^{cde}	3.73^{e}	4.56^{i}	5.17^{abcde}	6.45^{e}
T_{16}	4.54^{bcd}	5.06^{bcde}	5.02^{cd}	4.42^{abcd}	5.04^{cd}	5.10^{bcde}	5.05^{abc}	5.12^{cde}	5.71^{abcd}	6.70^{bc}
T_{17}	4.60^{abc}	4.90^{cdefg}	4.88^{defg}	4.70^{ab}	4.70^{hij}	4.98^{bcde}	4.52^{d}	4.63^{hi}	4.61^{defg}	6.38^{ef}
T_{18}	4.68^{ab}	4.86^{cdefg}	4.84^{efgh}	4.70^{ab}	4.52^{k}	5.06^{bcde}	4.46^{d}	4.99^{def}	5.30^{abcde}	6.45^{e}
T_{19}	4.50^{bcd}	4.69^{defgh}	4.71^{hi}	4.48^{abcd}	4.71^{ghij}	4.62^{dgf}	4.74^{abcd}	4.98^{def}	5.00^{bcdefg}	6.45^{e}
T_{20}	4.69^{ab}	5.20^{abc}	5.10^{c}	4.88^{a}	5.00^{d}	5.42^{abcd}	4.82^{abcd}	5.11^{de}	5.40^{abcde}	6.75^{b}
$T_{0(1)}$	4.50^{bcd}	4.92^{cdefg}	4.62^{ij}	4.60^{abc}	4.82^{fgh}	5.00^{bcde}	5.12^{ab}	4.89^{efg}	5.00^{bcdefg}	6.45^{e}
$T_{0(2)}$	4.65^{ab}	5.00^{bcdef}	4.70^{hi}	4.66^{abc}	4.80^{efgh}	4.84^{bcde}	5.04^{abc}	5.03^{def}	5.16^{abcde}	6.44^{e}

Grouping was done by Duncan's Multiple Range Test

Eventhough there was difference between treatments none showed significant difference compared to either or both the controls during May and maximum weight was for GA 100 ppm + 1% urea (6.35 g) and minimum for paclobutrazol 500 ppm + 1% urea (3.77 g). The former showed significant difference from all other treatments by June (6.85 g) and all paclobutrazol treatments recorded low weight of 100 florets.

4.2.10 Length of a floret

There was significant difference among the length of a floret, when the different bioregulator treatments were compared. But the variation was not consistent and the difference was significant among the controls during certain months. Comparatively lower floret length was recorded for paclobutrazol treatments, especially those treated with initial spray of 1000 ppm followed by 250 ppm with and without urea during the periods of study (Table 20).

4.2.11 Diameter of the floret

Variation in the diameter of the floret at bimonthly intervals is given in Table 21. Though the difference was not statistically significant compared to controls. GA and BA containing treatments in general recorded a higher floret diameter. In most cases lowest diameter of the floret was recorded for paclobutrazol containing treatments. During certain months CCC containing treatments also recorded higher floret diameter.

Table 20. Effect of bioregulators on the length of a floret (cm) in crossandra during different months

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	4.02^{a}	4.08^{abc}	4.20^{ab}	3.59^{abc}	3.59^{fg}	4.05^{ab}	3.23^{ab}	3.53^{ef}	4.15^{a}	3.95^{ab}
T_2	3.95^{a}	3.84^{abcde}	4.03^{bc}	3.74^{ab}	3.73^{cde}	4.0^{abc}	3.74^{cd}	3.39^{fg}	3.90^{bc}	3.95^{ab}
T_3	3.98^{a}	4.12^{a}	4.10^{abc}	3.80^{a}	3.83^{bc}	4.07^{a}	3.80^{bc}	3.93^{b}	4.02^{ab}	3.90^{ab}
T_4	4.0^{a}	3.94^{abcd}	4.03^{bc}	3.63^{abc}	3.82^{bc}	3.73^{cde}	3.80^{a}	4.15^{a}	4.07^{ab}	4.05^{a}
T_5	3.9^{a}	3.90^{abcde}	3.95^{cd}	3.53^{abc}	3.43^{hi}	3.5^{ef}	3.64^{ef}	3.6^{de}	3.14^{g}	4.0^{a}
T_6	3.98^{a}	3.93^{abcd}	4.03^{bc}	3.75^{ab}	3.85^{ab}	3.78^{bcde}	3.63^{f}	3.68^{cde}	3.17^{g}	3.95^{ab}
T_7	4.0^{a}	4.10^{ab}	4.08^{abc}	3.6^{abc}	3.15^{j}	3.90^{abcd}	3.45^{hi}	3.43^{fg}	3.53^{e}	4.0^{a}
T_8	3.78^{a}	3.86^{abcde}	3.93^{cde}	3.62^{abc}	3.23^{j}	3.90^{abcd}	3.68^{def}	3.53^{ef}	3.53^{e}	3.75^{abc}
T_9	3.80^{a}	3.73^{cde}	3.65^{fg}	3.39^{c}	3.58^{g}	3.73^{cde}	3.20^{k}	3.34^{g}	3.28^{fg}	3.95^{ab}
T_{10}	3.44^{a}	3.54^{e}	3.45^{g}	3.49^{abc}	3.69^{def}	3.69^{de}	3.55^{g}	3.42^{fg}	3.4^{ef}	3.35^{def}
T_{11}	3.62^{a}	3.59^{de}	3.48^{g}	3.4^{c}	3.43^{hi}	3.0^{g}	3.31^{j}	3.28^{g}	3.28^{fg}	3.65^{bcd}
T_{12}	3.43^{h}	3.55^{e}	3.65^{fg}	3.62^{abc}	3.53^{gh}	3.33^{f}	3.43^{i}	3.4^{fg}	3.3^{fg}	3.3^{efg}
T_{13}	3.44^{a}	3.78^{abcde}	3.73^{ef}	3.56^{abc}	3.72^{cde}	3.8^{abcd}	3.52^{gh}	3.79^{bc}	3.94^{bc}	3.1^{fg}
T_{14}	3.59^{a}	3.89^{abcde}	3.63^{fg}	3.45^{bc}	3.4^{i}	3.89^{abcd}	3.88^{a}	3.89^{b}	3.94^{bc}	3.25^{efg}
T_{15}	3.53^{a}	3.83^{abcde}	3.98^{cd}	3.48^{bc}	3.84^{ab}	3.93^{abcd}	3.44^{i}	3.63^{de}	3.55^{e}	3.10^{fg}
T_{16}	3.45^{a}	3.81^{abcde}	3.98^{cd}	3.65^{abc}	3.63^{efg}	3.79^{abcd}	3.78^{bc}	3.60^{de}	3.41^{ef}	3.10^{fg}
T_{17}	3.57^{a}	3.73^{cde}	3.98^{cde}	3.74^{ab}	3.83^{bc}	4.0^{abc}	3.84^{ab}	3.59^{de}	3.75^{cd}	3.4^{def}
T_{18}	3.63^{a}	3.86^{abcde}	4.0^{bcd}	3.49^{abc}	3.8^{bcd}	3.73^{cde}	3.80^{bc}	3.69^{cd}	3.90^{bc}	3.4^{def}
T_{19}	1.93^{b}	3.82^{abcde}	4.25^{a}	3.48^{abc}	3.83^{bc}	3.75^{cde}	3.83^{ab}	3.62^{de}	3.59^{de}	3.15^{fg}
T_{20}	3.53^{a}	3.74^{bcde}	3.80^{def}	3.66^{abc}	3.72^{cde}	3.65^{de}	3.69^{def}	3.33^{g}	3.55^{e}	3.35^{def}
$T_{0(1)}$	3.61^{a}	3.81^{abcde}	3.90^{cde}	3.57^{abc}	3.54^{g}	3.70^{de}	3.70^{de}	3.80^{cd}	3.78^{cd}	3.50^{cde}
$T_{0(2)}$	3.40^{a}	3.80^{abcde}	4.2^{ab}	3.70^{abc}	3.95^{a}	3.73^{cde}	3.80^{cd}	3.68^{de}	3.80^{c}	3.00^{g}

Grouping was done by Duncan's Multiple Range test

Table 21. Effect of bioregulators on the diameter of floret (cm) in crossandra at bimonthly intervals

Treat-ments	At flowering	2 MAF	4 MAF	6 MAF	8 MAF
T_1	2.6^{b}	2.3^{a}	2.3^{b}	2.8^{ab}	2.8^{abc}
T_2	2.7^{a}	2.3^{a}	2.4^{ab}	2.7^{abcd}	2.9^{a}
T_3	2.6^{ab}	2.4^{a}	2.7^{a}	2.6^{aabcd}	2.5^{cdef}
T_4	2.6^{ab}	2.3^{a}	2.3^{ab}	2.7^{abcd}	2.8^{ab}
T_5	2.4^{bc}	2.2^{a}	2.4^{b}	2.7^{abcd}	2.2^{abc}
T_6	2.6^{ab}	2.5^{a}	2.3^{b}	2.7^{abcd}	2.6^{bcde}
T_7	2.5^{ab}	2.3^{a}	2.5^{ab}	2.6^{abcd}	2.5^{cdef}
T_8	2.5^{ab}	2.3^{a}	2.4^{b}	2.6^{abcd}	2.4^{efg}
T_9	2.4^{abc}	2.1^{a}	2.3^{b}	2.5^{cd}	2.5^{cdef}
T_{10}	2.2^{cd}	2.5^{a}	2.3^{b}	2.5^{d}	2.2^{g}
T_{11}	2.4^{bc}	2.5^{a}	1.9^{c}	2.5^{cd}	2.6^{bcdef}
T_{12}	2.1^{d}	2.3^{a}	2.3^{b}	2.5^{d}	1.8^{h}
T_{13}	2.4^{bc}	2.3^{a}	2.4^{b}	2.5^{cd}	2.4^{efg}
T_{14}	2.6^{ab}	2.6^{a}	2.5^{ab}	2.6^{abcd}	2.3^{fg}
T_{15}	2.4^{bc}	2.1^{a}	2.5^{ab}	2.7^{abcd}	2.5^{defg}
T_{16}	2.5^{ab}	2.3^{a}	2.5^{ab}	2.5^{bcd}	2.5^{bcdef}
T_{17}	2.5^{ab}	2.3^{a}	2.3^{b}	2.5^{cd}	2.7^{abcd}
T_{18}	2.5^{ab}	2.4^{a}	2.3^{b}	2.7^{abc}	2.7^{abcde}
T_{19}	2.5^{ab}	2.3^{a}	2.4^{b}	2.8^{a}	2.6^{bcde}
T_{20}	2.6^{ab}	2.4^{a}	2.3^{b}	2.5^{d}	2.7^{abc}
$T_{0(1)}$	2.6^{ab}	2.2^{a}	2.4^{ab}	2.5^{bcd}	2.6^{bcdef}
$T_{0(2)}$	2.4^{abc}	2.3^{a}	2.5^{ab}	2.7^{abcd}	2.4^{efg}

Grouping was done by Duncan's Multiple Range Test
MAF - Months after flowering

4.2.12 Length of spike

Effect of field treatments, different months and their interaction were found to be significant in the case of the length of spike in crossandra.

Effect of field treatments

On an average, maximum spike length was recorded for BA 200 ppm + 1% urea which differ significantly from all others (28.0 cm), followed by GA 200 ppm (24.3 cm), while spike length was minimum (7.7 cm) for paclobutrazol 250 ppm + 1% urea (Table 18 and Plates 4, 5 and 6).

Effect of months

Length of spike recorded was maximum (25.6 cm) during the month of November, followed by December (24.7 cm) and they were on par and differed significantly from all others (Table 17). Minimum spike length (11.8 cm) was recorded during May which was immediately preceeded by spike length during April (12.6 cm).

Interaction effect

Interaction effect was found to be significant and maximum length of spike was noted for GA 200 ppm (34.1 cm) during the month of January and minimum for paclobutrazol 250 ppm treatment (3.8 cm) during the month of April (Table 22).

During September spike length was maximum (30.6 cm) for CCC 1000 ppm + 1% urea treatment followed by BA 200 ppm + 1% urea (28.4 cm).

Plate 4. Characters of GA treated crossandra spikes

Plate 5. Characters of BA treated crossandra spikes

Plate 6. Characters of paclobutrazol treated crossandra spikes

A spike at an early stage

B spike at an advanced stage


T1
T2
T3
T4
A
B
A
B
A
B
A
B


A
B
A
B
A
B
A
B

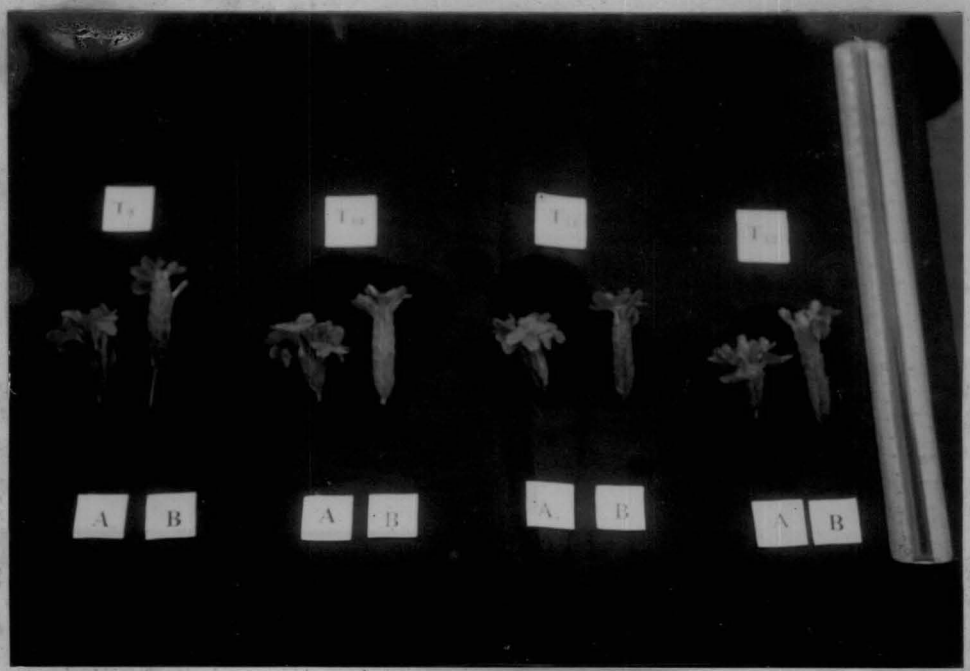
A
B
A
B
A
B
A
B

Table 22. Length of spike (cm) in crossandra, as influenced by bioregulator treatments and different months

Treat-ments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	19.3^{cde}	23.0^{c}	26.3^{bc}	29.7^{a}	24.5^{efghi}	21.1^{efg}	22.5^{ab}	14.1^{e}	15.0^{cd}	15.3^{defg}
T_2	21.1^{bcd}	24.7^{c}	30.9^{ab}	30.0^{a}	20.8^{j}	21.0^{efg}	16.4^{def}	16.0^{cd}	13.9^{cdef}	17.5^{cde}
T_3	22.6^{abcd}	23.4^{c}	30.3^{ab}	27.8^{a}	34.1^{a}	29.8^{a}	16.9^{def}	17.8^{b}	18.7^{b}	21.5^{ab}
T_4	20.3^{bcde}	22.5^{c}	30.2^{ab}	30.0^{a}	26.0^{cdef}	24.3^{cde}	14.1^{fgh}	11.2^{fg}	14.7^{cde}	18.8^{bcd}
T_5	22.8^{abcd}	27.9^{abc}	26.5^{bc}	29.6^{a}	27.0^{cde}	22.1^{def}	15.4^{efg}	16.2^{c}	11.9^{ef}	17.0^{cdef}
T_6	17.1^{def}	24.7^{c}	28.5^{ab}	25.1^{a}	25.4^{defgh}	20.2^{fgh}	17.3^{def}	10.0^{gh}	15.5^{c}	13.5^{fghi}
T_7	27.3^{abc}	30.7^{ab}	33.2^{a}	26.1^{a}	28.8^{bc}	18.5^{ghi}	17.6^{cdef}	11.9^{f}	11.7^{fgh}	22.8^{a}
T_8	28.4^{ab}	31.6^{a}	30.1^{ab}	29.3^{a}	31.3^{ab}	29.0^{ab}	25.9^{a}	28.5^{a}	24.2^{a}	21.8^{ab}
T_9	11.9^{efg}	10.8^{b}	12.2^{d}	11.7^{bc}	10.8^{k}	12.8^{j}	10.9^{ghi}	7.3^{i}	6.1^{jk}	13.8^{efgh}
T_{10}	11.9^{efg}	12.2^{d}	11.9^{d}	16.6^{b}	10.8^{k}	12.0^{jk}	9.3^{i}	8.7^{hi}	7.5^{ij}	9.8^{ij}
T_{11}	9.8^{fg}	9.1^{d}	10.8^{d}	11.5^{bc}	11.1^{k}	11.6^{jk}	10.5^{hi}	3.8^{j}	6.1^{jk}	8.3^{jk}
T_{12}	7.4^{g}	8.3^{d}	8.0^{d}	8.8^{c}	9.9^{k}	9.0^{k}	7.9^{i}	7.7^{i}	4.5^{k}	5.5^{k}
T_{13}	16.8^{def}	23.2^{c}	31.5^{ab}	28.5^{a}	22.0^{ij}	24.8^{cd}	14.6^{efgh}	11.0^{fg}	12.9^{cdef}	10.8^{hij}
T_{14}	20.5^{bcde}	24.3^{c}	30.9^{ab}	29.0^{a}	28.2^{cd}	25.9^{bc}	18.9^{bcde}	10.3^{g}	13.4^{cdef}	17.0^{cdef}
T_{15}	19.4^{cde}	25.8^{bc}	30.9^{ab}	28.4^{a}	24.7^{efghi}	24.1^{cde}	17.7^{cdef}	14.7^{de}	12.6^{def}	16.0^{cdef}
T_{16}	30.6^{a}	25.2^{bc}	28.5^{ab}	24.4^{a}	25.9^{defg}	17.1^{hi}	18.6^{bcdef}	14.5^{e}	11.9^{ef}	15.3^{defg}
T_{17}	16.0^{defg}	24.5^{c}	29.9^{ab}	24.7^{a}	22.7^{hij}	21.1^{efg}	20.1^{bcd}	12.4^{f}	9.1^{ghi}	12.0^{ghij}
T_{18}	20.4^{bcde}	25.2^{bc}	26.6^{bc}	27.1^{a}	24.8^{efghi}	16.2^{i}	15.3^{efg}	8.1^{i}	8.3^{ij}	15.0^{defg}
T_{19}	21.3^{bcd}	23.2^{c}	22.1^{c}	28.0^{a}	21.5^{j}	19.6^{fgh}	18.3^{bcdef}	11.3^{fg}	8.9^{hij}	19.3^{abc}
T_{20}	18.3^{def}	23.3^{c}	28.6^{ab}	25.6^{a}	22.2^{ij}	21.8^{defg}	14.1^{fgh}	12.0^{f}	8.0^{ij}	21.8^{ab}
$T_{0(1)}$	21.3^{bcd}	25.1^{c}	26.9^{bc}	26.5^{a}	23.0^{ghij}	20.4^{fgh}	19.2^{bcde}	14.0^{e}	11.9^{efg}	17.3^{cdef}
$T_{0(2)}$	23.3^{abcd}	24.6^{c}	28.5^{ab}	24.9^{a}	23.2^{fghij}	22.8^{cdef}	22.0^{abc}	16.0^{cd}	12.0^{def}	16.8^{cdef}

Grouping was done by Duncan's Multiple Range Test

The latter maintained a higher spike length through out the study period and it recorded maximum spike length during October (31.6 cm), March (25.9 cm), April (28.5 cm) and May (24.8 cm). Minimum spike length during September was for paclobutrazol 250 ppm + 1% urea treatment (7.4 cm) and this treatment showed minimum length of spike throughout the period of study except during April, when paclobutrazol 250 ppm recorded minimum (3.8 cm) length of spike. During November maximum length of spike was for BA 200 ppm treatment (33.2 cm) followed by CCC 500 ppm (31.5 cm), but during December GA 100 ppm and 200 ppm each with 1% urea recorded (30 cm) maximum spike length. During January and February GA 200 ppm treatment recorded maximum spike length (34.1 cm and 29.8 cm respectively) followed by BA 200 ppm + 1% urea BA 200 ppm treatment which recorded maximum spike length (22.8 cm) during June also.

4.2.13 Diameter of the spike

Significant difference among the treatments was noticed for the diameter of spike during different months (Table 23). During the month of September maximum diameter was recorded for paclobutrazol 500 ppm (4.04 cm) and it differed significantly from all others. GA 100 ppm + 1% urea recorded minimum diameter (3.3 cm).

None of the treatments showed significant difference from the controls during October and November, but maximum diameter was recorded for BA 200 ppm + 1% urea and minimum for non-sprayed control. Difference from control were insignificant during December, but GA 200 ppm recorded maximum diameter (3.53 cm) and paclobutrazol 500 ppm + 1% urea the minimum (2.68 cm).

Table 23. Diameter of a spike in crossandra (cm) as influenced by different bioregulator treatments and months

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	3.35^{fgh}	3.67^{bcde}	3.40^{bcd}	3.07^{abc}	2.95^{efghi}	3.18^{abcd}	3.28^{abc}	2.83^{bcd}	3.18^{abc}	3.00^{d}
T_2	3.30^{h}	3.63^{cde}	3.23^{cd}	3.12^{abc}	2.75^{i}	3.30^{abc}	3.19^{bcde}	3.00^{abcd}	2.85^{bcdefg}	3.00^{d}
T_3	3.65^{bcd}	4.17^{a}	3.15^{d}	3.53^{a}	3.00^{cdefgh}	3.28^{abc}	2.94^{defg}	3.28^{ab}	3.18^{abc}	3.40^{bc}
T_4	3.63^{bcde}	3.88^{abcde}	3.15^{d}	2.93^{bc}	2.93^{fghi}	3.05^{abcde}	3.08^{cdef}	3.12^{abc}	3.00^{abcdef}	3.35^{bcd}
T_5	3.58^{bcdefg}	4.05^{abcd}	3.25^{bcd}	3.35^{ab}	3.16^{bcde}	3.20^{abcd}	2.24^{abc}	3.48^{ab}	3.12^{abcde}	3.05^{cd}
T_6	3.69^{bc}	3.89^{abcde}	3.30^{bcd}	3.10^{abc}	3.20^{bc}	3.13^{abcd}	3.45^{ab}	2.88^{abcd}	2.71^{defg}	3.25^{bcd}
T_7	3.71^{d}	4.14^{ab}	3.30^{bcd}	3.32^{ab}	3.30^{b}	3.50^{a}	3.09^{cdef}	2.83^{bcd}	2.85^{bcdefg}	3.45^{b}
T_8	3.60^{bcdef}	3.90^{abcde}	3.98^{a}	3.53^{a}	3.28^{b}	3.17^{abcd}	3.50^{a}	3.33^{ab}	3.13^{abcd}	3.15^{bcd}
T_9	4.04^{a}	4.12^{abc}	3.38^{bcd}	3.20^{ab}	3.05^{cdefg}	2.74^{bcde}	3.08^{cdef}	2.89^{abcd}	2.75^{cdefg}	4.0^{a}
T_{10}	$3.48^{bcdefgh}$	3.91^{abcde}	3.45^{bcd}	2.68^{c}	3.53^{a}	3.07^{abcde}	2.38^{h}	2.60^{cd}	2.60^{fgh}	3.15^{bcd}
T_{11}	3.42^{defgh}	3.74^{abcde}	3.45^{bcd}	3.18^{abc}	2.98^{defgh}	3.10^{abcde}	2.75^{g}	2.35^{d}	2.43^{gh}	3.10^{bcd}
T_{12}	$3.48^{bcdefgh}$	3.69^{abcde}	3.43^{bcd}	2.85^{bc}	3.13^{bcdef}	3.22^{abcd}	2.90^{efg}	3.13^{abc}	3.13^{abcd}	3.20^{bcd}
T_{13}	3.32^{gh}	3.54^{e}	3.23^{cd}	3.00^{bc}	3.28^{b}	3.13^{abcd}	2.90^{efg}	2.88^{abcd}	3.08^{abcde}	3.10^{bcd}
T_{14}	3.43^{cdefgh}	3.58^{de}	3.53^{bcd}	3.32^{ab}	2.98^{defgh}	2.47^{e}	2.85^{fg}	2.88^{abcd}	3.20^{abc}	3.20^{bcd}
T_{15}	3.37^{efgh}	3.59^{de}	3.58^{abc}	3.20^{ab}	2.83^{hi}	2.68^{cde}	3.07^{cdef}	3.23^{abc}	3.13^{abcd}	3.10^{bcd}
T_{16}	3.36^{fgh}	3.63^{cde}	3.53^{bcd}	3.08^{abc}	3.10^{bcdef}	3.43^{a}	3.23^{abcd}	3.49^{a}	3.32^{a}	3.10^{bcd}
T_{17}	3.43^{cdefgh}	3.66^{bcde}	3.33^{bcd}	3.30^{ab}	3.05^{cdefg}	3.13^{abcd}	3.00^{cdefg}	2.89^{abcd}	2.17^{h}	3.00^{b}
T_{18}	$3.56^{bcdefgh}$	3.74^{abcde}	3.25^{bcd}	3.27^{ab}	3.15^{bcde}	3.32^{ab}	3.02^{cdefg}	3.02^{abc}	2.65^{efg}	3.30^{bcd}
T_{19}	3.40^{defgh}	3.57^{de}	3.53^{bcd}	3.23^{ab}	2.95^{efghi}	2.75^{bcde}	3.23^{abcd}	2.85^{abcd}	3.22^{ab}	3.15^{bcd}
T_{20}	$3.47^{bcdefgh}$	3.60^{de}	3.33^{bcd}	3.30^{ab}	3.03^{cdefgh}	3.18^{abcd}	3.23^{abcd}	2.60^{cd}	2.59^{fgh}	3.35^{bcd}
$T_{0(1)}$	3.63^{bcde}	3.69^{abcde}	3.65^{ab}	3.25^{ab}	3.18^{bcd}	3.25^{abcd}	3.19^{bcde}	2.90^{abcd}	3.05^{abcdef}	3.45^{b}
$T_{0(2)}$	3.33^{gh}	3.53^{e}	3.48^{bcd}	3.15^{abc}	2.88^{ghi}	2.64^{de}	3.13^{cdef}	3.13^{abc}	2.84^{bcdefg}	3.0^{d}

Grouping was done by Duncan's Multiple Range Test

The latter recorded maximum diameter during the next month, which was significantly higher than all others, while GA 100 ppm + 1% urea recorded the minimum at this time (2.75 cm).

In February and March BA 200 ppm recorded maximum spike diameter and minimum for CCC 500 ppm + 1% urea and paclobutrazol 500 ppm + 1% urea respectively for these months. During April and May CCC 1000 ppm + 1% urea recorded maximum spike diameter (3.49 cm and 3.32 cm respectively) and minimum by paclobutrazol 250 ppm (2.35 cm) and $ZnSO_4$ 0.25% (2.17 cm) during the two months respectively. Significantly higher spike diameter was found for paclobutrazol 500 ppm (4 cm), compared to all other treatments and minimum for non-sprayed control, $ZnSO_4$ 0.25% and GA 100 ppm with and without 1% urea (3 cm each) during June.

4.2.14 Longevity of a floret in an intact spike

Studies revealed that, in most of the months there was no significant difference in the longevity of a floret in an intact spike compared to controls (Table 24). Longevity ranged from two days to four days. During certain months the difference was significant among the treatments, but the effect was not consistent throughout the period of study.

4.2.15 Longevity of a spike in the field

Significant difference among treatments were observed in the case of the longevity of a spike from the emergence to the senescence of the last floret (Table 25).

Table 24. Longevity of a floret in an intact spike of crossandra (in days) as influenced by bioregulator treatments

Treat-ments	At flowering	2 MAF	4 MAF	6 MAF	8 MAF	10 MAF
T_1	2.25^{ef}	3.0^{a}	3.0^{ab}	2.5^{abc}	2.5^{a}	2.0^{cd}
T_2	2.25^{ef}	3.25^{a}	2.5^{ab}	2.75^{ab}	2.25^{a}	2.25^{bcd}
T_3	2.0^{f}	3.5^{a}	2.5^{ab}	2.5^{abc}	2.50^{a}	2.25^{bcd}
T_4	2.25^{ef}	3.25^{a}	2.5^{ab}	1.75^{cd}	3.0^{a}	2.25^{bcd}
T_5	2.75^{de}	3.5^{a}	2.75^{ab}	2.25^{abcd}	2.75^{a}	2.25^{bcd}
T_6	3.5^{abc}	3.5^{a}	2.25^{ab}	1.75^{cd}	2.75^{a}	2.75^{abc}
T_7	3.0^{cd}	3.0^{a}	2.0^{b}	2.75^{ab}	2.5^{a}	3.25^{a}
T_8	3.75^{ab}	3.0^{a}	2.75^{ab}	3.0^{a}	2.5^{a}	2.75^{abc}
T_9	3.75^{ab}	2.75^{a}	2.5^{ab}	1.5^{d}	2.0^{a}	2.75^{abc}
T_{10}	3.5^{abc}	3.25^{a}	2.25^{ab}	2.0^{bcd}	2.5^{a}	2.5^{abcd}
T_{11}	4.0^{a}	3.0^{a}	2.5^{ab}	2.0^{bcd}	2.25^{a}	2.25^{bcd}
T_{12}	3.75^{ab}	3.0^{a}	3.0^{ab}	2.0^{bcd}	2.0^{a}	3.0^{ab}
T_{13}	3.75^{ab}	3.5^{a}	3.25^{a}	2.5^{abc}	2.75^{a}	2.5^{abcd}
T_{14}	4.0^{a}	3.0^{a}	3.25^{a}	2.0^{bcd}	2.0^{a}	2.25^{bcd}
T_{15}	3.25^{bcd}	3.0^{a}	3.25^{a}	2.25^{abcd}	2.0^{a}	2.25^{bcd}
T_{16}	2.75^{de}	3.5^{a}	2.75^{ab}	2.0^{bcd}	2.25^{a}	2.0^{cd}
T_{17}	2.0^{f}	2.5^{a}	2.25^{ab}	1.75^{cd}	2.25^{a}	3.25^{a}
T_{18}	2.25^{ef}	2.75^{a}	2.0^{b}	2.0^{bcd}	2.0^{a}	1.75^{d}
T_{19}	3.25^{bcd}	3.5^{a}	2.5^{ab}	1.5^{d}	2.0^{a}	2.5^{abcd}
T_{20}	3.50^{abc}	3.0^{a}	3.0^{ab}	2.0^{bcd}	2.0^{a}	2.0^{cd}
$T_{0(1)}$	3.0^{cd}	2.75^{a}	3.0^{ab}	2.25^{abcd}	2.0^{a}	2.0^{cd}
$T_{0(1)}$	3.25^{bcd}	2.5^{a}	2.25^{ab}	2.0^{bcd}	2.75^{a}	2.0^{cd}

Grouping was done based on Duncan's Multiple Range Test
MAF - Months after flowering

Table 25. Effect of bioregulators on the spike longevity in the field (in days) in crossandra during different months

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	45.0^{abc}	42.8^{bcde}	40.3^{efg}	50.4^{abc}	46.8^{aabcde}	46.0^{bcdef}	42.8^{bcd}	39.0^{bcde}	37.5^{bc}	35.5^{cdefg}
T_2	41.2^{bcdefg}	44.0^{bcd}	42.0^{cdefg}	51.3^{abc}	42.9^{bcdef}	46.8^{bcde}	36.0^{de}	33.4^{gh}	33.5^{de}	32.8^{fghi}
T_3	45.2^{abc}	42.4^{cde}	38.0^{fg}	45.3^{bcde}	47.0^{abcde}	56.8^{a}	40.3^{cde}	40.3^{bcd}	38.0^{bc}	38.8^{abc}
T_4	48.8^{a}	44.6^{bc}	41.5^{cdefg}	50.0^{abcd}	44.8^{abcdef}	44.5^{bcdefg}	38.5^{cde}	39.0^{bcde}	44.3^{a}	34.3^{defg}
T_5	46.0^{ab}	46.1^{b}	40.8^{efg}	48.5^{abcdef}	48.2^{abc}	40.0^{efg}	41.5^{bcde}	34.8^{fgh}	36.5^{bcd}	37.8^{abcde}
T_6	43.8^{abcde}	40.9^{defgh}	37.0^{g}	48.3^{abcde}	42.8^{bcdef}	37.8^{efg}	38.5^{cde}	39.3^{i}	39.5^{b}	28.8^{i}
T_7	44.3^{abcd}	41.9^{cdefg}	40.3^{efg}	44.0^{cde}	36.8^{f}	36.8^{fg}	37.5^{cde}	34.5^{fgh}	33.1^{de}	37.8^{abcde}
T_8	49.0^{a}	49.7^{a}	49.3^{a}	43.8^{cde}	34.0^{cdef}	39.3^{efg}	39.3^{cde}	45.3^{a}	39.5^{b}	37.8^{abcde}
T_9	31.4^{h}	33.7^{m}	39.0^{efg}	42.5^{de}	38.5^{cdef}	42.8^{cdefg}	39.0^{cde}	34.5^{fgh}	31.0^{dfg}	40.3^{ab}
T_{10}	37.0^{fgh}	35.3^{klm}	39.5^{efg}	42.3^{e}	38.0^{def}	35.5^{g}	34.8^{e}	37.0^{def}	32.0^{ef}	37.0^{abcdef}
T_{11}	35.8^{gh}	36.8^{ijklm}	$39/3^{efg}$	44.0^{cde}	40.7^{bcdef}	52.0^{abc}	49.5^{a}	32.0^{hi}	24.3^{hi}	34.8^{cdefg}
T_{12}	36.2^{gh}	43.3^{bcd}	39.8^{efg}	46.5^{abcde}	41.0^{bcdef}	45.5^{bcdef}	42.3^{bcd}	36.0^{efg}	32.0^{ef}	33.5^{efgh}
T_{13}	36.0^{gh}	36.8^{jklm}	46.8^{abcd}	48.9^{abcde}	42.5^{bcdef}	46.5^{bcdef}	40.5^{cde}	34.6^{fgh}	36.5^{bcd}	32.0^{ghi}
T_{14}	41.8^{bcdefg}	46.1^{bc}	46.8^{abcd}	52.1^{ab}	50.3^{ab}	52.8^{ab}	47.5^{ab}	37.5^{cdef}	34.5^{cde}	35.8^{cdefg}
T_{15}	39.4^{cdefgh}	39.9^{efghi}	47.3^{abc}	53.9^{a}	54.1^{a}	50.5^{abcd}	48.0^{ab}	36.5^{efg}	34.8^{cde}	41.3^{a}
T_{16}	38.4^{defgh}	37.9^{hijkl}	43.3^{bcdef}	48.8^{abcde}	44.0^{bcdef}	43.0^{bcdefg}	44.1^{abc}	41.3^{b}	32.3^{ef}	38.0^{abcd}
T_{17}	35.3^{gh}	35.8^{jklm}	42.8^{cdefg}	45.6^{bcde}	37.8^{ef}	37.8^{efg}	42.5^{bcd}	37.0^{def}	37.5^{gh}	32.8^{fghi}
T_{18}	$40.5^{bcdefgh}$	42.0^{cdef}	44.4^{abcde}	50.7^{abc}	45.0^{abcd}	39.8^{efg}	40.5^{bcd}	29.0^{i}	28.8^{fg}	36.3^{bcdefg}
T_{19}	38.8^{cdefgh}	35.1^{lm}	41.0^{defg}	50.4^{abc}	43.5^{bcdef}	41.0^{defg}	50.5^{a}	34.8^{fgh}	36.8^{ef}	37.5^{abcde}
T_{20}	33.1^{h}	35.8^{jklm}	42.5^{cdefg}	50.8^{abc}	35.8^{f}	42.8^{cdefg}	41.4^{bcde}	35.3^{fgh}	23.5^{i}	29.5^{hi}
$T_{0(1)}$	$39.7^{bcdefgh}$	38.5^{ghijk}	43.5^{abcdef}	46.8^{abcde}	40.5^{bcdef}	38.0^{efg}	37.9^{cde}	40.8^{bc}	35.0^{cde}	36.0^{bcdefg}
$T_{0(2)}$	42.8^{abcdef}	38.9^{fghij}	49.0^{ab}	48.5^{abcde}	40.5^{bcdef}	41.0^{defg}	39.8^{cde}	41.0^{bc}	34.3^{cde}	37.5^{abcde}

Grouping was done by Duncan's Multiple Range Test

During the month of September maximum spike longevity was recorded for BA 200 ppm + 1% urea (49 days) followed by GA 200 ppm + 1% urea (48.8 days). Longevity was minimum for paclobutrazol 500 ppm (31.4 days). BA 200 ppm + 1% urea recorded maximum longevity during October (49.7 days) and November (49.3 days) also, during that period minimum longevity was recorded for paclobutrazol 500 ppm (33.7 days) and BA 100 ppm + 1% urea (37 days) respectively. During December, January and June CCC 1000 ppm recorded maximum longevity of the spike (53.9, 54.1 and 41.3 days respectively) and the minimum was recorded for paclobutrazol 500 ppm + 1% urea, $ZnSO_4$ 0.5% + 1% urea and BA 100 ppm + 1% urea treatments respectively.

During Feburary CCC 500 ppm + 1% urea treatment ranked the second (52.8 days), the first being GA 200 ppm (56.8 days), both differed significantly from controls, and minimum longevity was for paclobutrazol 500 ppm + 1% urea treatment (35.5). During March longevity was maximum for $ZnSO_4$ 0.5% treatment (50.5 days) followed by paclobutrazol 250 ppm (49.5 days) while minimum longevity was recorded for paclobutrazol 500 ppm + 1% urea (34.8 days). During April and May maximum longevity was recorded for BA 200 ppm + 1% urea (45.3 days) and GA 200 ppm + 1% urea (44.3 days) respectively and minimum for $ZnSO_4$ 0.25 % + 1% urea (29 days) and $ZnSO_4$ 0.5% + 1% urea (23.5 days) respectively.

4.2.16 Stalk length of the spike

Variation among bioregulator treatments, different months and their interaction were found to be significant (Plates 4, 5 and 6).

Table 26. Effect of bioregulator treatments on the stalk length of the spike (cm) in crossandra during various months

Treatments	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
T_1	8.9^{ef}	11.9^{d}	14.4^{c}	12.3^{bcde}	11.3^{de}	9.1^{abc}	8.4^{b}	2.3^{fgh}	3.4^{c}	4.9^{fghi}
T_2	11.0^{cd}	13.7^{d}	15.4^{bc}	12.6^{bcd}	6.6^{h}	6.2^{cdefg}	5.2^{fg}	4.0^{c}	1.6^{fg}	7.6^{cdef}
T_3	12.8^{bc}	13.4^{d}	17.8^{abc}	13.3^{abc}	15.6^{a}	10.2^{ab}	3.5^{i}	3.6^{cd}	5.1^{b}	12.3^{ab}
T_4	10.4^{de}	13.0^{d}	15.6^{abc}	12.6^{bcd}	11.3^{de}	8.1^{bcde}	2.0^{k}	2.1^{fghi}	1.9^{ef}	8.4^{cde}
T_5	10.1^{def}	16.9^{ab}	15.4^{bc}	12.2^{bcde}	11.1^{def}	8.5^{bcde}	1.9^{k}	5.8^{b}	1.9^{ef}	5.8^{efgh}
T_6	10.0^{def}	17.0^{ab}	14.1^{c}	12.2^{bcde}	13.6^{abcd}	8.3^{bcde}	4.7^{gh}	2.6^{efg}	4.9^{b}	3.4^{hijk}
T_7	12.8^{bc}	16.2^{bc}	19.2^{ab}	11.9^{bcde}	12.6^{bcde}	6.1^{cdefg}	3.5^{i}	3.5^{cde}	1.8^{f}	9.5^{bcd}
T_8	14.9^{a}	19.1^{a}	20.1^{a}	16.1^{a}	14.9^{ab}	12.6^{a}	11.4^{a}	12.9^{a}	8.8^{a}	10.3^{abc}
T_9	2.1^{g}	2.2^{e}	2.1^{d}	1.2^{f}	2.2^{i}	0.5^{h}	1.0^{l}	0.2^{l}	0.2^{hij}	2.8^{hijk}
T_{10}	0.8^{gh}	1.1^{e}	0.8^{d}	1.9^{f}	1.4^{i}	1.0^{h}	0.7^{l}	0.3^{l}	0.2^{hij}	0.8^{jk}
T_{11}	0.6^{gh}	0.7^{e}	1.4^{d}	2.1^{f}	1.5^{i}	0.7^{h}	1.7^{k}	0.2^{l}	0.0^{j}	1.4^{jk}
T_{12}	0.1^{h}	0.2^{e}	0.4^{d}	0.9^{f}	1.6^{i}	0.9^{h}	0.5^{l}	0.6^{kl}	0.2^{ij}	0.0^{k}
T_{13}	8.2^{f}	12.9^{d}	15.8^{abc}	12.3^{bcde}	10.1^{efg}	7.2^{bcdef}	2.0^{k}	1.5^{hijk}	2.5^{de}	1.6^{ijk}
T_{14}	9.1^{def}	13.3^{d}	18.1^{abc}	13.9^{ab}	14.5^{abc}	8.8^{bcd}	5.0^{fgh}	1.2^{ijkl}	3.0^{cd}	4.8^{fghi}
T_{15}	8.6^{ef}	13.3^{d}	15.1^{bc}	12.4^{bcde}	8.0^{gh}	7.1^{bcdef}	6.5^{c}	3.6^{cd}	1.8^{ef}	4.0^{ghij}
T_{16}	9.5^{def}	13.6^{d}	14.1^{c}	10.7^{cde}	11.1^{def}	4.1^{fgh}	6.4^{cd}	3.5^{cde}	0.8^{hi}	5.3^{efgh}
T_{17}	8.7^{ef}	14.3^{cd}	16.6^{abc}	11.9^{bcde}	12.0^{cde}	5.9^{cdefg}	5.9^{de}	2.9^{def}	0.9^{gh}	3.2^{hijk}
T_{18}	9.6^{def}	14.0^{cd}	14.4^{c}	11.4^{bcde}	10.1^{efg}	2.8^{gh}	3.0^{ij}	0.8^{kl}	0.4^{hij}	4.9^{fghi}
T_{19}	9.7^{def}	12.6^{d}	14.1^{c}	11.7^{bcde}	8.4^{fgh}	5.4^{defg}	5.3^{ef}	1.8^{ghij}	1.8^{f}	6.8^{defg}
T_{20}	13.1^{ab}	13.6^{d}	14.5^{c}	9.6^{e}	10.9^{def}	8.3^{bcde}	2.8^{j}	4.1^{c}	1.7^{f}	13.0^{a}
$T_{0(1)}$	10.2^{de}	12.7^{d}	14.3^{c}	10.2^{de}	10.0^{efg}	5.2^{efg}	4.5^{h}	2.5^{fg}	0.9^{gh}	7.8^{cdef}
$T_{0(2)}$	8.8^{ef}	14.2^{cd}	16.9^{abc}	12.0^{bcde}	11.3^{de}	9.4^{abc}	8.5^{b}	1.0^{jkl}	2.1^{ef}	3.1^{hijk}

Grouping was done by Duncan's Multiple Range Test

Effect of field treatments

On an average maximum stalk length was recorded by BA 200 ppm + 1% urea (14.1cm), followed by GA 200 ppm (10.8 cm) and BA 200 ppm (9.7 cm). First two differed significantly from each other and all other treatments. Stalk length was very low in all paclobutrazol treatments and on an average minimum was recorded for paclobutrazol 250 ppm + 1% urea (0.5 cm) (Table 18).

Effect of months

Month effect was very significant (Table 17) and stalk length was maximum during November (13.2 cm), followed by October (11.8 cm) and minimum during May (2.1 cm).

Interaction effect

Interaction effect of treatments and months was significant and maximum stalk length was recorded for BA 200 ppm + 1% urea treatment during the month of November (20.1 cm), and even stalk less spikes were produced by paclobutrazol 250 ppm and without and with urea during May and June respectively (Table 26).

Stalk length recorded was maximum in BA 200 ppm + 1% urea treatment, throughout the study period except during the month of January and June (8.8 cm to 20.1 cm), while during January maximum stalk length of spike was recorded for GA 200 ppm (15.6 cm) and during June for $ZnSO_4$ 0.5% + 1% urea treatment (13 cm). Next to this treatments was GA 200 ppm which maintained a higher stalk length during most of the months. Paclobutrazol treatments recorded

lower stalk length throughout the study period and in most of the months, they were significantly lower than all other treatments (Plates 4 5 and 6)

4.3 Effect on pigmentation

4.3.1 Chlorophyll content of leaves

Chlorophyll contents (Chlorophyll 'a', 'b' and total content) were depicted in Fig.4.

Chlorophyll 'a' content was found to be more in plants treated with CCC 500 ppm, CCC 1000 ppm, CCC 1000 ppm + 1% urea and paclobutrazol 500 ppm (above 1.0 mg/g) on unit weight basis. Treatment with GA 100 ppm, GA 200 ppm and BA 100 ppm showed lower content of chlorophyll 'a' (below 0.85 mg/g).

Maximum chlorophyll 'b' content was recorded for paclobutrazol 500 ppm + 1% urea treatment (0.89 mg/g) and it differed significantly from non-sprayed control (524.5 mg/g), and it also showed significant difference from most of the treatments. Minimum chlorophyll 'b' was recorded for CCC 500 ppm + 1 % urea (0.47 mg/g), but showed no significant difference from control.

When both chlorophyll 'a' and chlorophyll 'b' are taken together, paclobutrazol 500 ppm + 1% urea recorded the maximum content (1·832 mg/g) which showed significant difference from BA 200 ppm (1.38 mg/g), CCC 1000 ppm + 1% urea (1·375 mg/g) and paclobutrazol 250 ppm (1·358 mg/g).

4.3.2 Carotene content of the flower

Total carotene content of the flowers was found to be maximum in plants treated with CCC at 500 ppm concentration (0.49 mg/l) followed by paclobutrazol

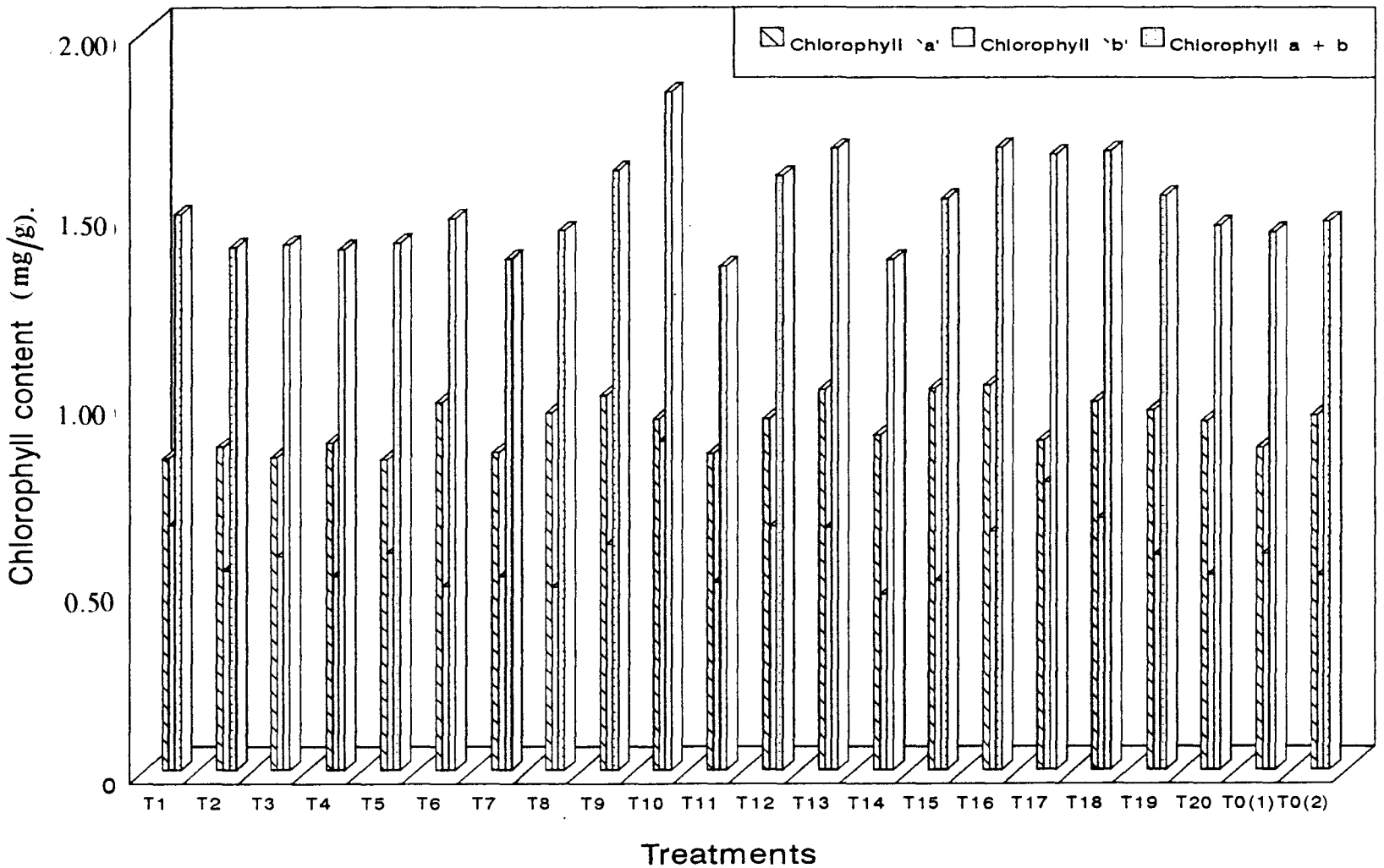

Fig.4. Different bioregulator treatments causing changes in leaf chlorophyll content in crossandra

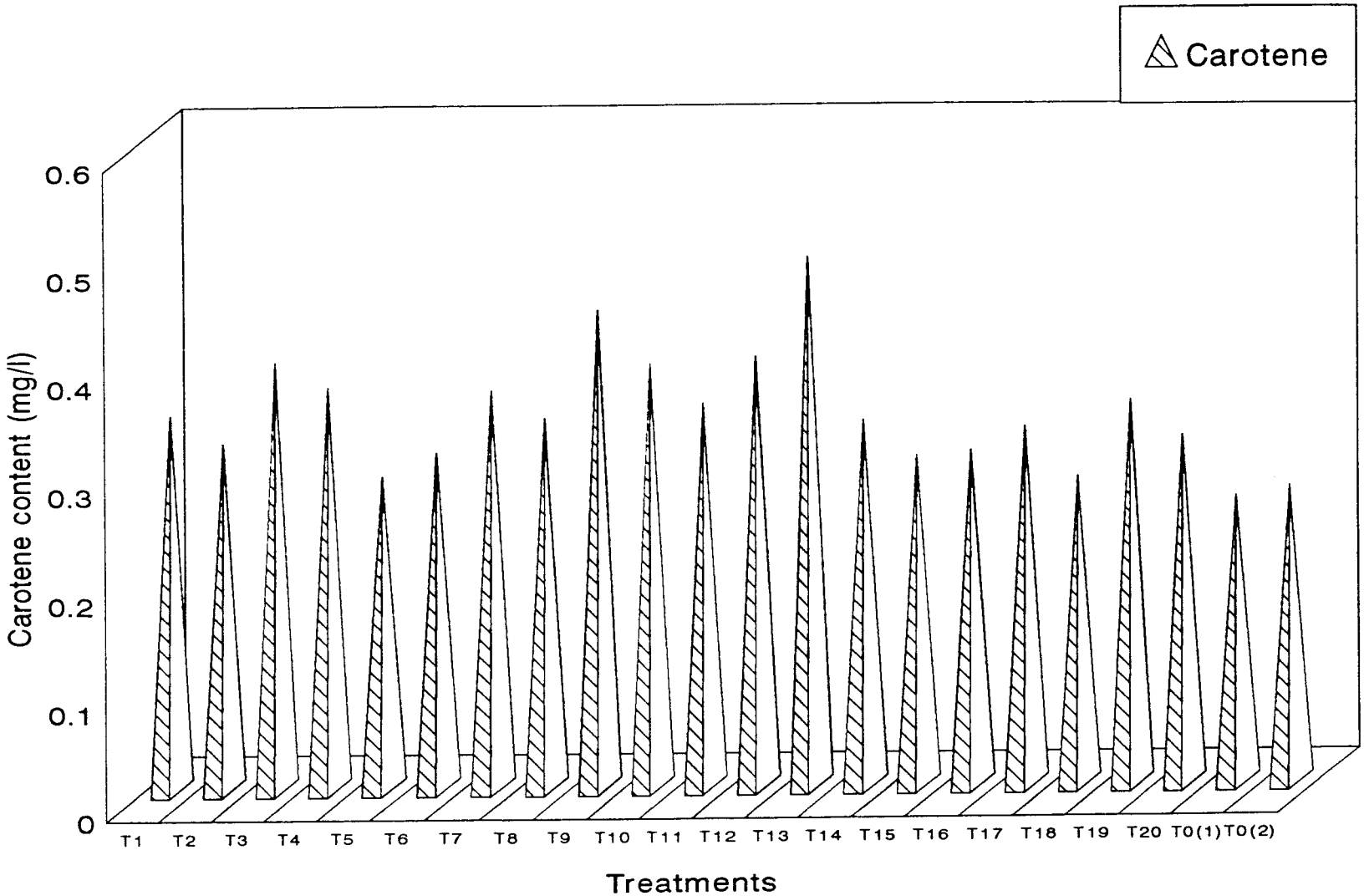

Fig.5. Carotene content of crossandra flowers as influenced by different bioregulators

500 ppm (0.44 mg/l) and the former differed significantly from both the controls. Minimum total carotene in flowers was recorded for the controls (0.27 mg/l in both water sprayed and non-sprayed control). CCC 500 ppm treatment also showed significant increase in total carotene content of flowers compared to BA 100 ppm (0.29 mg/l) and $ZnSO_4$ 0.25% + 1% urea (0.28 mg/l) (Fig.5).

4.4 Postharvest life of cut spike

4.4.1 Pulsing and storage

4.4.1.1 Harvest index of the spike

Spikes of different stages were examined to find their suitability to keep in vases. Spikes on which fresh floret first started opening was not suitable, because the floret opening will not continue and the opened ones were smaller in size and have a pale appearance. Spikes on which floret opening has already started (6-8 florets opened) were found to be attractive, with 4-6 fully opened and 4-8 appeared florets; and exhibit better postharvest behaviour. Spikes in the advanced stages of floret opening showed a tendency to bent and break, and hence not suitable. So spikes with 6-8 florets opened was selected for the study.

4.4.1.2 Preliminary studies

Preliminary studies with three chemicals each at two levels and $AgNO_3$ at 4 levels showed that among sucrose 5% and 10% treatments, pulsing with 10% sucrose gave maximum storage life (36 hours) compared with sucrose 5% (24 h). 8-HQ 500 ppm gave more storage life than 8-HQ 250 ppm. Among the two $CoCl_2$ treatments $CoCl_2$ 200 ppm was found to be better than $CoCl_2$ 100 ppm and the $AgNO_3$ treatments (1.0%, 0.5%, 0.1% and 0.05%), produced the same effect (18

hours). Hence $AgNO_3$ 0.05% concentration was included in further studies. Among the other three chemicals the concentrations which gave better storage life was included. Precooling was also tried. Among the 12 hour and 24 hour duration there was no difference in the storage life and so the 12 hour precooling was selected for further studies.

4.4.1.3 Effect of field treatments in pulsing, precooling and storage

Spikes from all the field treatments were subjected to all the pulsing, precooling and storage treatments. To know the effect of field treatments, data from one of the pulsing (10% sucrose 500 ppm 8-HQ) and storage (bamboo basket) treatments and one of the precooling (12 hours) and storage treatments (bamboo basket) were analysed statistically.

4.4.1.3.1 Effect of field treatments and pulsing in postharvest characters of the spike

The postharvest spike characters recorded were fresh weight, solution absorption, postharvest loss of weight, postharvest storage life, time taken for complete opening of florets in a spike and number of florets opened at a time.

The data showed that among the treatments significant difference was noted in the fresh weight of the spikes (Table 27). In general spikes from BA treatments maintained a higher fresh weight.

Solution absorption measured for 12 hour and 24 hour pulsing showed that, in 12 hour pulsing spikes treated with paclobutrazol 250 ppm and BA 200 ppm showed significantly higher solution absorption while for 24 hour pulsing BA

Table 27. Effect of field treatments on fresh weight, solution absorption and postharvest loss of weight after pulsing and storage

Treatment	Fresh weight (g)	Solution absorption		Post harvest loss of weight	
		12 h	24 h	12 h	24 h
T_1	2.17	0.85	0.90	0.57	0.26
T_2	1.46	0.60	0.85	0.68	0.22
T_3	1.74	0.70	0.95	1.09	0.18
T_4	1.50	0.80	0.80	0.40	0.26
T_5	1.68	0.80	1.20	0.50	0.24
T_6	1.54	0.80	1.30	0.45	0.26
T_7	2.25	1.00	0.90	0.55	0.26
T_8	2.08	0.70	0.90	0.31	0.36
T_9	1.74	0.70	0.75	0.66	0.34
T_{10}	1.62	0.70	0.80	0.32	0.48
T_{11}	1.58	1.30	0.95	0.39	0.23
T_{12}	2.09	0.75	0.75	0.41	0.54
T_{13}	1.80	0.80	1.00	0.63	0.10
T_{14}	2.07	0.60	0.80	0.62	0.25
T_{15}	2.02	0.60	0.95	0.28	0.27
T_{16}	1.83	0.70	1.10	0.29	0.24
T_{17}	1.69	0.70	0.65	0.43	0.51
T_{18}	1.80	0.70	0.65	0.48	0.17
T_{19}	1.61	0.75	0.90	0.58	0.31
T_{20}	1.86	0.75	0.95	0.56	0.35
$T_{0(1)}$	2.08	0.60	0.65	0.37	0.38
$T_{0(2)}$	2.08	0.60	0.65	0.25	0.28
CD(0.05)	0.67*	0.39*	0.52*	0.40*	0.13*

* significant at 5 % level

100 ppm and BA 100 ppm + 1% urea treatments showed significantly higher solution uptake.

Studies revealed that minimum postharvest loss in weight was recorded for spikes from CCC 500 ppm treatment (0.6 g) and maximum for paclobutrazol 250 ppm + 1% urea and $ZnSO_4$ 0.25% treatments after 24 hour pulsing. In the case of 12 hour pulsing except GA 200 ppm none showed significant difference in postharvest loss of weight (Table 27).

Under the particular pulsing and storage conditions, storage life was similar for spikes from all the field treatments and it was 40 hours for 12 hour pulsing and 30 hours for 24 hour pulsing.

Spikes from none of the field treatments showed complete floret opening after storage. In the case of pulsing with 10% sucrose + 500 ppm 8-HQ, it was observed that after the maximum possible storage period, spikes continued floret opening for two or to a maximum of three days.

Number of florets opened at a time was two in most cases, but in certain cases towards the end of postharvest life, only one floret opened at a time.

4.4.1.3.2 Effect of field treatments in precooling

Fresh weight showed significant difference among treatments, and the maximum fresh weight was recorded for paclobutrazol 500 ppm + 1% urea (3.08 g) and minimum for CCC 1000 ppm (1.25 g). There was no difference among the field treatments in the postharvest storage life (30 hours in bamboo basket). Regarding the postharvest loss of weight, maximum value was recorded for paclobutrazol 500 ppm

Table 28. Effect of field treatments on fresh weight, vase life and postharvest loss of weight after precooling and storage in bamboo basket

Treatment	Fresh weight (g)	Vase life in days after precooling and storage of 30 hr	Post harvest loss of weight (g)
T_1	2.07	1.5	0.50
T_2	1.73	1.5	0.40
T_3	1.80	1.5	0.60
T_4	1.80	0.5	0.31
T_5	2.6	2.0	0.43
T_6	2.11	1.5	0.36
T_7	2.12	1.0	0.70
T_8	1.67	1.0	0.81
T_9	2.20	0.5	0.90
T_{10}	3.08	1.0	1.19
T_{11}	1.38	1.0	0.42
T_{12}	1.29	1.0	0.51
T_{13}	1.37	1.0	0.55
T_{14}	2.13	1.5	0.68
T_{15}	1.25	1.5	0.45
T_{16}	2.24	1.5	0.58
T_{17}	1.85	2.0	0.35
T_8	2.52	1.0	0.43
T_{19}	1.64	1.0	0.57
T_{20}	2.26	1.5	0.63
$T_{0(1)}$	2.22	1.0	0.38
$T_{0(2)}$	2.89	1.0	0.59
CD(0.05)	0.923*	1.18*	0.57*

* significant at 5 % level

and minimum for GA 200 ppm + 1% urea (Table 28). Time taken for complete opening of florets in a spike showed no significant difference among the treatments. All continued floret opening for one or two days, after the above mentioned storage period. Number of florets opened at a time was two in most cases and there was no significant difference among the treatments for this character.

4.4.1.4 Effect of pulsing and precooling treatments

Among the field treatments,spikes from BA 200 ppm + 1% urea, which showed more desirable traits,as more stalk length and better appearance was selected to study the effect of pulsing, precooling and storage. Data pertaining to the postharvest characters of the spikes collected from the above treatment were subjected to statistical analysis and the results are presented in Table 29.

Storage life was found to be maximum with 15% sucrose + 500 ppm 8-HQ (88 days) on an average followed by 15% sucrose + 200 ppm $CoCl_2$ (63 days). Distilled water control and precooling recorded minimum storage life (39 days). Since the same field treatment was used the difference in the fresh weight among the different pulsing treatments were very less. Fresh weight recorded was maximum for spikes which received 10% sucrose + 50 ppm 8-HQ + 0.05% $AgNO_3$ (1.87 g) and minimum for spikes which received precooling (1.68 g).

Among the pulsing treatments, maximum solution absorption was recorded for 10% sucrose + 500 ppm 8-HQ + 0.05% $AgNO_3$ treated spikes (1.2 ml) and the minimum (0.77 ml) for sucrose 10% + 8-HQ 500 ppm treatment. Minimum postharvest loss of weight was recorded when the spikes were pulsed with sucrose 10% + $CoCl_2$ 200 ppm. Postharvest loss of weight recorded was maximum

Table 29. Effect of different pulsing treatments on fresh weight, solution absorption, storage life and postharvest loss of weight of crossandra spikes

Treatment	Fresh weight (g)	Solution absorption	Storage life (hrs)	Post harvest loss of weight (g)
P_0	1.71	0.77	39	0.56
P_1	1.77	0.85	56	0.32
P_2	1.81	1.00	59	0.31
P_3	1.87	1.20	58	0.45
P_4	1.74	1.07	63	0.51
P_5	1.73	1.01	88	0.55
P_6	1.68	-	39	0.50
CD(0.05)	0.18*	0.22*	5*	0.10*

* significant at 5% level

for control (0.56 g) followed by 15% sucrose + 500 ppm 8-HQ (0.55 g) and 15% sucrose + 200 ppm $CoCl_2$ (0.51 g). Precooling also resulted in higher postharvest loss of weight (0.51 g). Number of florets opened at a time showed no significant difference among the treatments. Only two florets opened at a time in all the treatments. Towards the end of postharvest life only one floret opened at a time in certain cases.

4.4.1.5 Effect of pulsing duration

Among the two pulsing duration, postharvest storage life showed not much difference,and was 59 hours for 12 hour treated ones and 56 hours for 24 hour treated ones on an average (Table 30). The spikes continued floret opening for one or two days after the maximum possible storage. In most cases number of florets opened at a time was two, but towards the end of postharvest life only one floret opened at a time.

In the case of both 12 hour and 24 hour treatment fresh weight showed not much variation. Pulsing for 24 hours gave more solution absorption (1.03 ml) than pulsing for 12 hours (0.66 ml). Postharvest loss of weight showed only slight variation, and it was 0.45 g for 12 hour pulsing and 0.47 g for 24 hour pulsing.

4.4.1.6 Effect of storage treatments

The studies revealed that all refrigerated storage conditions (Plate 6) recorded a high storage period compared to ambient storage (Table 31). Maximum storage life was recorded in polythene bag 300 guage under refrigeration (101 hours) followed by polythene bag 200 guage under refrigeration (91 hours). Storage life was minimum in bamboo basket (35 hours) immediately preceeded by corrugated

Table 30. Effect of pulsing duration on fresh weight, solution absorption, storage life and postharvest loss of weight of crossandra spikes

Treatment	Fresh weight (g)	Solution absorption	Storage life (hrs)	Post harvest loss of weight (g)
12 hr	1.78	0.66	59	0.45
24 hr	1.74	1.03	56	0.47
CD(0.05)	NS	0.12 *	2.7 *	NS

* significant at 5 % level

Table 31. Effect of different storage treatments on fresh weight, storage life and postharvest loss of weight of crossandra spikes

Treatment	Fresh weight (g)	Storage life (hrs)	Post harvest loss of of weight (g) .
S_0	1.87	35	0.56
S_1	1.84	44	0.57
S_2	1.91	37	0.65
S_3	1.76	46	0.48
S_4	1.71	40	0.61
S_5	1.68	44	0.52
S_6	1.63	79	0.26
S_7	1.72	91	0.28
S_8	1.73	101	0.23
CD(0.05)	0.21 *	5.8 *	0.12 *

* significant at 5% level

carton with paper bits (37 hours). Among the ambient storage conditions (Plate 5), storage period was maximum in perforated cardboard box with wet newsprint (46 hours).

After the recorded periods of storage, the spikes could continue floret opening for one or two days. Number of florets opened at a time was two in most cases, but towards the end of postharvest life only one floret opened at a time.

There was no significant difference in the fresh weight of the spikes as the same field treatment was selected for the study. Postharvest loss of weight was very low in refrigerated storage conditions (0.23 g to 0.26 g). Postharvest loss of weight recorded was maximum for spikes stored in corrugated carton with paper bits (0.65 g) (Table 31). Among ambient condition storage, spikes stored in perforated cardboard box with wet newsprint recorded minimum postharvest loss of weight (0.48 g).

4.4.1.7 Interaction effect of pulsing its duration precooling and storage

Regarding the interaction of pulsing and its duration, maximum storage life was for those spikes which were given pulsing for 24 hours with 15% sucrose + 500 ppm 8-HQ and minimum for those which received precooling and control pulsing (Table 32). While storage and pulsing duration interaction when considered maximum storage period (106 hours) for those spikes stored in 300 guage polythene bags and pulsed for 24 hours, while minimum (31 hours) for those stored in bamboo basket after 12 hour pulsing (Table 33). Regarding pulsing, precooling and storage interaction maximum storage period was recorded for polythene bags 200 guage and 300 guage both under refrigerated condition and received pulsing with 15% sucrose

Plate 7. Flowers stored under refrigerated conditions in polythene bags


S6
S7
S8

Table 32. Interaction effect of pulsing precooling treatments and pulsing duration on fresh weight, solution absorption, storage life and postharvest loss of weight in crossandra

Treatment	Fresh weight (g)		Solution absorption		Storage life (hrs)		Post harvest loss of weight (g)	
	24 hr	12 hr	24 hr	12 hr	24 hr	12 hr	24 hr	12 hr
P_0	1.72	1.70	1.18	0.84	38	40	0.56	0.57
P_1	1.71	1.82	0.84	0.69	52	60	0.42	0.21
P_2	1.77	1.86	1.03	0.67	59	59	0.34	0.28
P_3	1.82	1.92	1.18	0.83	58	58	0.47	0.43
P_4	1.74	1.75	1.50	0.90	59	67	0.47	0.54
P_5	1.72	1.75	1.47	0.69	88	87	0.51	0.59
Precooling	1.68	-	-	-	39	-	0.50	-
CD(0.05)	0.26*		0.31*		7.2!*		0.15*	

* significant at 5% level

Table 33. Interaction effect of storage and pulsing duration on fresh weight, storage life and postharvest loss of weight in crossandra spikes

Treatment	Fresh weight (g)		Storage life (hrs)		Post harvest loss of of weight (g)	
	24 hr	12 hr	24 h4	12 hr	24 hr	12 hr
S_0	1.90	1.83	31	39	0.57	0.55
S_1	1.68	2.01	43	44	0.69	0.46
S_2	1.82	2.00	34	40	0.68	0.63
S_3	1.91	1.62	46	47	0.52	0.43
S_4	1.63	1.78	36	44	0.54	0.68
S_5	1.71	1.64	43	46	0.49	0.56
S_6	1.58	1.68	74	84	0.29	0.23
S_7	1.72	1.72	94	89	0.23	0.24
S_8	1.70	1.75	106	95	0.20	0.25
CD(0.05)	0.30 *		8.2 *		0.17 *	

* significant at 5% level

+ 200 ppm 8-HQ (162 hours) (Table 34). Storage period was lowest for those which received pulsing with distilled water (control) and stored in bamboo basket (24 hours).

Pulsing and its duration interaction causes the maximum solution absorption for those pulsed with 15% sucrose + 200 ppm $CoCl_2$ for 24 hours (1.5 ml) and minimum for those pulsed with 10% sucrose + 200 ppm $CoCl_2$ for 12 hours (Table 32).

After maximum possible storage as mentioned above all the spikes continued floret opening for one or two days. But after a specified period of storage of 72 hours none of the spikes stored under ambient condition storage continued floret opening, irrespective of the pulsing received. While under all refrigerated storage conditions they retained the capacity for floret opening, the maximum being recorded for spikes stored in 200 and 300 guage polythene, both under refrigerated conditions and received pulsing with 15% sucrose + 500 ppm 8-HQ (6 days). Number of florets opened at a time was two in all cases and towards the end of postharvest life only one floret opened at a time.

In the case of pulsing and storage interaction minimum postharvest loss of weight was recorded for spikes pulsed with 15% sucrose + 200 ppm $CoCl_2$ and stored under refrigerated conditions in 300 guage polythene bags (0.09 g) and maximum for spikes which received control pulsing and stored in corrugated carton with paper bits (Table 35). In the case of interaction between pulsing and its duration 12 hour pulsing with 10% sucrose + 500 ppm 8-HQ and 10% sucrose + 200 ppm $CoCl_2$ recorded minimum postharvest loss of weight (Table 32). Interaction between storage and pulsing duration showed that all refrigerated storage conditions

Table 34. Interaction effect of pulsing, precooling and storage on the sotrage life (hours) of cut crossandra spikes

Treatments	P_0	P_1	P_2	P_3	P_4	P_5	Precooling
S_0	24.0	35.0	35.0	35.0	34.0	50.5	30.0
S_1	30.0	41.0	49.0	42.0	51.5	59.0	32.0
S_2	27.0	42.0	35.0	36.0	37.5	53.5	30.0
S_3	32.0	57.0	52.0	44.0	45.0	62.0	32.0
S_4	30.0	40.0	39.5	38.5	45.0	57.0	30.0
S_5	30.0	49.5	40.0	49.5	54.0	57.0	30.0
S_6	59.0	78.0	78.0	78.0	78.0	126.0	56.0
S_7	60.0	78.0	84.0	96.0	102.0	162.0	56.0
S_8	60.0	84.0	120.0	102.0	120.0	162.0	56.0

CD(0.05) = 15.3*

* significant at 5% level

Table 35. Interaction effect of pulsing, precooling and storage on the postharvest loss of weight (g) of cut crossandra spikes

Treatments	P_0	P_1	P_2	P_3	P_4	P_5	Precooling
S_0	0.715	0.245	0.170	0.850	0.685	0.405	0.87
S_1	0.550	0.365	0.305	0.565	0.630	0.865	0.74
S_2	0.875	0.505	0.335	0.645	0.720	0.785	0.70
S_3	0.710	0.400	0.285	0.550	0.520	0.520	0.35
S_4	0.675	0.345	0.535	0.530	0.745	0.650	0.80
S_5	0.560	0.330	0.600	0.205	0.795	0.720	0.46
S_6	0.415	0.240	0.375	0.320	0.075	0.196	0.18
S_7	0.325	0.165	0.055	0.240	0.285	0.375	0.19
S_8	0.265	0.255	0.140	0.175	0.090	0.430	0.22

CD(0.05) = 0.312 *

* significant at 5% level

gave less postharvest loss of weight (0.20 to 0.29 g) irrespective of the pulsing duration (Table 33).

4.4.2 Effect onvase life

All the field treatments were subjected to treatment with different vase solutions and the whole data was analysed to get the effect of field treatments, effect of vase soltuions and their interaction on the vase life and other postharvest characters of crossandra spikes.

4.4.2.1 Effect of bioregulator treatments

Effect of bioregulator treatments on postharvest characters of crossandra spike are presented in Table 36. Data showed that spikes from treatments which received GA 200 ppm and BA 200 ppm + 1% urea registered highest fresh weight (2.45 g and 2.2 g respectively). GA 200 ppm treated spike differed significantly from all others. Minimum fresh weight was recorded for palnts treated with paclobutrazol 250 ppm (1.04 g) and it differed significantly from all other treatments.

Maximum solution absorption per day (1.52 ml) was registered by spikes from treatment with GA 200 ppm + 1% urea which showed significant difference from controls (0.90 and 1.07 ml/day). Solution absorption was least for spikes from treatment with paclobutrazol 250 ppm (0.7 ml/day).

The studies revealed that vase life was maximum for spikes from plants which received BA 100 ppm treatment (8.65 days) and minimum for spikes from

Table 36. Effect of different bioregulator treatments on vase life and postharvest characters of cut crossandra spikes

Treatment	Fresh weight (g)	Solution absorption (ml)	Post harvest loss of weight (g)	Vase life (days)
T_1	2.04^{bcd}	1.02^{bcdf}	0.41^{abcdef}	7.88^{b}
T_2	1.93^{bcdef}	1.10^{bcde}	0.29^{defgh}	7.75^{bc}
T_3	2.45^{a}	1.31^{abc}	0.32^{cdefgh}	7.75^{bc}
T_4	1.93^{bcdef}	1.52^{a}	0.44^{abcd}	7.63^{bc}
T_5	1.79^{defg}	0.82^{ef}	$0.34^{bcdefgh}$	8.65^{a}
T_6	1.93^{bcdef}	1.05^{bcde}	0.24^{fgh}	7.88^{b}
T_7	2.15^{bc}	1.25^{abcd}	0.51^{a}	7.75^{bc}
T_8	2.20^{ab}	0.99^{cdef}	0.53^{a}	7.75^{bc}
T_9	1.76^{defg}	1.22^{abcd}	$0.33^{bcdefgh}$	6.13^{h}
T_{10}	1.57^{g}	1.08^{bcde}	0.23^{gh}	7.38^{cde}
T_{11}	1.04^{h}	0.70^{f}	0.21^{h}	7.5^{bcd}
T_{12}	1.73^{defg}	1.07^{bcde}	0.22^{gh}	7.00^{efg}
T_{13}	1.63^{efg}	1.27^{abc}	0.29^{defgh}	7.38^{cde}
T_{14}	1.95^{bcde}	1.36^{ab}	0.49^{ab}	6.75^{fg}
T_{15}	1.91^{bcdef}	1.26^{abc}	0.42^{abcde}	6.63^{g}
T_{16}	1.75^{defg}	1.49^{a}	0.27^{efgh}	6.63^{g}
T_{17}	1.86^{cdefg}	1.21^{abcd}	0.46^{abc}	7.63^{bc}
T_{18}	1.61^{efg}	1.30^{abc}	$0.37^{abcdefgh}$	8.50^{a}
T_{19}	1.87^{bcdefg}	1.11^{bcde}	$0.38^{abcdefgh}$	7.13^{def}
T_{20}	1.60^{fg}	0.99^{cdef}	0.26^{efgh}	6.00^{h}
$T_{0(1)}$	1.74^{defg}	1.07^{bcde}	$0.31^{abdefgh}$	7.75^{bc}
$T_{0(2)}$	2.00^{bcd}	0.90^{def}	0.46^{abc}	7.75^{bc}

Grouping was done by Duncan's Multiple Range Test

$ZnSO_4$ 0.5% + 1% urea treatment (6 days), and the former showed significant difference from all other treatments.

Maximum postharvest loss of weight was recorded for spikes from BA 200 ppm + 1% urea treatment (0.53 g) and minimum for spikes from paclobutrazol 250 ppm treatment (0.21 g).

4.4.2.2 Effect of vase solution

Data on various postharvest parameters are presented in Table 37. Fresh weight of the spike was found to be significantly higher in 3% sucrose + 200 ppm 8-HQ treatment, while the other three showed no significant difference among them. Solution absorption (ml/day) was found to be maximum in treatment with 3% sucrose + 200 ppm 8-HQ (1.28 ml/day) which differed significantly from the others.

Vase life was found to be significantly different in all the treatments. Treatment with 3% sucrose + 100 ppm $CoCl_2$ gave the maximum life in vase (8.2 days) while distilled water control gave minimum vase life (6.2 days). Postharvest loss of weight was maximum for treatment with 3% sucrose + 200 ppm 8-HQ (0.39 g) and minimum for 3% sucrose + 100 ppm $CoCl_2$ (0.3 g).

4.4.2.3 Interaction effect of treatments and vase solutions

Vase life recorded was maximum (10 days) in treatments $ZnSO_4$ 0.25%, $ZnSO_4$ 0.25% + 1% urea, both kept in solution containing 3% sucrose + 100 ppm $CoCl_2$ (Table 39). Minimum vase life was recorded for spikes from paclobutrazol 500 ppm kept in solution containing 3% sucrose + 200 ppm 8-HQ + 50 ppm

Table 37. Effect of vase solutions on vase life and postharvest characters of cut crossandra spikes

Treatment	Fresh weight (g)	Solution absorption (ml)	Vase life (days)	Post harvest loss of weight (g)
V_0	1.83^b	1.15^b	6.2^d	0.38^a
V_1	1.96^a	1.28^a	7.8^b	0.39^a
V_2	1.74^b	1.07^b	7.5^c	0.35^{ab}
V_3	1.82^b	1.07^b	8.2^a	0.30^b

Grouping was done by Duncan's Multiple Range Test

Table 38. Interaction effect of bioregulator treatments and different vase solutions on the fresh weight and solution absorption of cut crossandra spikes

Treatment	Fresh weight (g)				Solution absorption (ml)			
	V_0	V_1	V_2	V_3	V_0	V_1	V_2	V_3
T_1	1.67	2.32	2.01	2.15	0.73	1.48	0.79	1.09
T_2	1.72	2.33	1.76	1.89	0.57	1.80	1.30	0.75
T_3	2.19	2.89	2.15	2.56	1.23	1.68	1.04	1.30
T_4	2.15	2.32	1.38	1.86	1.41	1.20	1.78	1.69
T_5	1.91	1.90	1.59	1.79	0.65	0.84	0.94	0.87
T_6	1.96	2.08	1.67	2.00	1.18	1.06	0.94	1.04
T_7	2.01	2.82	1.93	1.84	1.31	1.58	1.40	0.70
T_8	2.16	2.29	2.27	2.09	1.29	0.94	0.67	1.07
T_9	1.75	1.83	1.73	1.73	1.70	1.27	1.10	0.83
T_{10}	1.35	2.04	1.54	1.34	1.0	1.19	0.96	1.17
T_{11}	1.01	1.25	0.80	1.11	0.80	0.58	0.66	0.76
T_{12}	2.17	1.60	1.22	1.93	0.85	1.43	1.24	0.78
T_{13}	1.71	1.45	1.58	1.80	1.90	0.94	1.37	0.87
T_{14}	2.11	2.21	1.81	1.67	1.35	1.91	0.56	1.62
T_{15}	1.59	2.11	2.33	1.62	1.56	1.54	1.07	0.89
T_{16}	1.92	1.69	1.89	1.49	1.87	1.28	1.50	1.31
T_{17}	2.65	1.44	1.46	1.82	1.30	1.51	1.30	0.74
T_{18}	1.47	1.62	1.64	1.73	1.34	1.83	0.90	1.25
T_{19}	1.81	2.05	2.06	1.63	0.94	1.36	1.07	1.08
T_{20}	1.49	1.48	1.75	1.67	0.94	0.41	1.08	1.52
$T_{0(1)}$	1.78	1.77	1.56	1.86	0.80	1.28	1.01	1.21
$T_{0(2)}$	1.72	1.69	2.07	2.48	0.67	1.15	0.87	0.92
CD(0.05)		0.548*				0.596*		

* Significant at 5 % level

Table 39. Interaction effect of bioregulator treatments and different vase solutions on the vase life and postharvest loss of weight of cut crossandra spikes

Treatment	Vase life (days)				Post harvest loss of weight (g)			
	V_0	V_1	V_2	V_3	V_0	V_1	V_2	V_3
T_1	8.0	6.5	8.0	9.0	0.38	0.58	0.17	0.50
T_2	7.5	7.5	7.0	9.0	0.30	0.32	0.18	0.35
T_3	5.5	7.5	9.5	8.5	0.50	0.43	0.24	0.10
T_4	6.5	9.0	6.0	9.0	0.82	0.27	0.23	0.43
T_5	7.5	9.5	8.0	9.5	0.52	0.42	0.25	0.16
T_6	6.0	8.5	8.0	9.0	0.30	0.22	0.13	0.33
T_7	6.5	8.0	9.0	7.5	0.54	0.75	0.43	0.32
T_8	6.5	8.0	7.0	9.5	0.37	0.53	0.78	0.43
T_9	6.0	7.5	4.0	7.0	0.11	0.77	0.15	0.31
T_{10}	6.0	6.5	10.0	7.0	0.25	0.17	0.20	0.31
T_{11}	5.0	10.0	7.0	8.0	0.24	0.32	0.08	0.22
T_{12}	8.0	5.5	7.5	7.0	0.20	0.28	0.04	0.38
T_{13}	4.5	9.5	7.0	8.5	0.45	0.25	0.29	0.17
T_{14}	5.5	7.0	7.5	7.0	0.46	0.68	0.71	0.13
T_{15}	4.5	7.0	7.0	8.0	0.30	0.50	0.49	0.40
T_{16}	6.5	8.0	5.5	6.5	0.29	0.16	0.25	0.39
T_{17}	6.0	7.0	7.5	10.0	0.71	0.43	0.30	0.41
T_{18}	7.0	8.0	9.0	10.0	0.23	0.49	0.44	0.31
T_{19}	5.0	7.5	8.5	7.0	0.40	0.27	0.59	0.29
T_{20}	6.0	7.0	5.0	6.0	0.28	0.23	0.30	0.23
$T_{0(1)}$	5.5	8.5	9.0	8.0	0.28	0.26	0.74	0.21
$T_{0(2)}$	6.5	7.5	8.5	8.5	0.40	0.24	0.84	0.35
CD(0.05)			0.785 *				0.274 *	

* significant at 5% level

$AgNO_3$ (4 days), the superior and inferior treatments showed significant difference from control (spikes from non-sprayed and water sprayed plants, and kept in distilled water).

Solution absorption showed significant difference among treatments (Table 36). Solution absorption was maximum for spikes from CCC 500 ppm + 1% urea treatment kept in 3% sucrose + 200 ppm 8-HQ solution (1.9 ml/day) followed by spike from CCC 500 ppm kept in distilled water. Minimum uptake of solution (0.41 ml/day) was recorded for spikes from $ZnSO_4$ 0.5% + 1% urea treatment, kept in solution containing 3% sucrose + 200 ppm 8-HQ.

Postharvest loss of weight recorded was minimum (Table 39) in spikes treated with paclobutrazol 250 ppm + 1% urea and kept in 3% sucrose + 200 ppm 8-HQ + 50 ppm $AgNO_3$ (0.04 g) and maximum in treatments with GA 200 ppm + 1% urea and distilled water (0.82 g).

Discussion

5. DISCUSSION

Crossandra, an important commercial flower crop of south India is priced for its attractive colour and long shelf life. Cultivar 'Delhi' which is triploid in nature producesdeep orange coloured flowers. As in other crops bioregulators are found to have significant influence in all the growth and developmental activities in ornamental flowering plants. Present study with GA, BA, CCC, paclobutrazol and $ZnSO_4$ in different levels either alone or in combination with urea also showed similar results. Results generated from the studies conducted to examine the effect of bioregulators on growth, flowering and postharvest life of crossandra is discussed here under.

In the present study it was found that growth promoters as GA and BA in general had a very significant influence in promoting growth. The growth retardant paclobutrazol was found to supress growth to the maximum level while CCC had not much influence. $ZnSO_4$ was also found to have little influence.

All the GA containing treatments are found to have significant positive influence on plant height compared to control (Table 1, Fig.1). Similar effects on increasing plant height by the application of GA was reported by Sayed and Muthuswamy (1974) in crossandra, Maharana and Pani (1982) in rose, Gowda and Gowda (1991) in jasmine and Shedeed *et al.* (1991) in china aster. Among the treatments containing GA, GA 200 ppm was found to have the maximum influence on height increase from the third month after treatment onwards, whereas an immediate effect was shown by GA in combination with urea. Singh *et al.* (1994) reported that the plant height in GA_3 treatment probably increased due to increase in

the cell division in the apical meristem and elongation of individual cells. Farooqui (1994) also reported increase in vegetative growth by GA treatment in rose.

Eventhough there was increase in plant height by BA treatments, none showed as much influence as GA. Among the treatments containing BA, height was relatively more for BA 100 ppm (Fig.1). All the paclobutrazol treatments recorded supression of height. Height remained almost static upto 10 months, but on the 12th month there was slight increase in height probably due to more favourable weather. Dalziel and Lawrence (1984) reported that the biochemical effect of paclobutrazol was as a gibberellin biosynthesis inhibitor and the reduction in the gibberellin level reduced the rate of cell division and expansion. Similar results of reduction of plant height by paclobutrazol was also reported by Gilbertz (1992) in chrysanthemum. He also suggested that earlier the application of growth retardants as paclobutrazol, shorter will be the plant stature. A complete growth retardation observed in the present study, also might be due to its application at a very early stage of growth, i.e., one month after planting. Higher concentrations (500, 1000 ppm) used might be another possible reason for complete suppression of growth.

But in the case of CCC 500 ppm and 1000 ppm with and without urea, no such suppression in plant height was observed, though CCC is also a gibberellin biosynthesis inhibitor. Similar results were observed in chrysanthemum with 5000, 10000 and 15000 ppm CCC (Shanmughum and Muthuswamy, 1974). According to them the absence of well known reaction viz., dwarfing by CCC and relatively more remarkable response to applied GA, may be due to the low endogenous level of GA in the cultivar studied.

All the GA and BA treatments showed a positive influence on plant spread (Table 2), the maximum being recorded by BA 200 ppm + 1% urea and GA 200 ppm treatments. Increase in the plant spread might be related with an increase in the number of branches and production of more number of leaves in general. Similar results on spread and number of shoots per plant was reported by Dahab *et al.* (1987) with GA in chrysanthemum. They opined that greater number of branches produced in GA treatment was attributed to the role of gibberellin in reducing apical dominance. Effect of GA on lateral branching was also reported in carnation by Mukhopadhyay (1990). Yamaguchi (1987) reported that BA application in carnation accelerated the production of secondary branches at lower nodes.

Treatment with CCC 500 ppm produced more number of branches, compared to controls and it produced even more number of leaves than GA 100 ppm + 1% urea, BA 100 ppm + 1% urea and BA 200 ppm treatments. Greater plant spread was also recorded in this treatment at early stages. An enhanced leaf number by CCC treatment was reported in chrysanthemum (Sen and Naik, 1973), which was attributed due to enhanced number of branches. But here in the present study higher concentrations in combination with urea (CCC 500 ppm + 1% urea and CCC 1000 ppm + 1% urea) failed to produce similar effects.

Eventhough Khader *et al.* (1985) reported an increase in plant height and number of branches in crossandra by $ZnSO_4$ in combination with NPK and FYM, similar results could not be obtained in the present study, probably due to the lack of the same nutrient balance provided in their experiment.

Application of paclobutrazol caused complete suppression of all vegetative characters which emphasised its action as an inhibitor of auxin/gibberellin biosynthesis.

In the case of leaf characters, leaf length (Table 4) and width (Table 5) showed no consistent variation, except that the paclobutrazol containing treatments always recorded a low value. But the leaf area recorded was always higher for BA 200 ppm + 1% urea and GA 200 ppm. For all other treatments leaf area showed not much significant variation, while it was significantly lower in all the paclobutrazol treatments throughout the year (Table 6). During six months after planting and eight months after planting higher leaf area was recorded for GA 100 ppm. Among treatments, variation in the leaf area was not so consistent. This might be due to the influence of climatic and environmental factors in leaf production. Higher leaf area for BA 200 ppm + 1% urea and GA 200 ppm thoughout the study period might be due to the maximum number of leaves produced by the two treatments. Minimum leaf area by treatment with paclobutrazol might be due to the lower number of leaves coupled with, lower length and width of the existing leaves. Similar results were obtained in Salvia by Mao *et al.* (1990).

Leaf colour also showed much variation with bioregulator treatments. The leaf colour was dark green with all paclobutrazol treatments. Total chlorophyll content was maximum for paclobutrazol 500 ppm + 1% urea (1.83 mg/g) followed by CCC 1000 ppm (1680 mg/g). Highest chlorophyll a content was recorded for CCC 1000 ppm + 1% urea (1037 mg/g), followed by CCC 1000 ppm (1029 mg/g), CCC 500 ppm (1024 mg/g) and paclobutrazol 500 ppm (1009 mg/g) and all the treatments were on par. Chlorophyll 'b' content was maximum for paclobutrazol 500 ppm +

1% urea (0.87 mg/g). An increase in the leaf chlorophyll content per unit leaf area by the application of growth retardants was reported in sunflower (Starman and Kelly, 1989). In the present study, though all the treatments with growth retardants showed higher values of chlorophyll, treatment differences were not significant in all the cases. It may be due to the fact that chlorophyll content in the present experiment was calculated on unit leaf weight basis and not based on unit leaf area.

Leaf crinkling due to excess dose of paclobutrazol as reported in Salvia by Mao *et al.* (1991) was observed in the present study also. Selective infestation by *Helicoverpa* on GA 100 ppm + 1% urea, GA 200 ppm + 1% urea, BA 200 ppm and BA 200 ppm + 1% urea may be due to more succulent nature of the plants subjected to the above treatments.

Regulation of flowering in many crops has been achieved by manipulation of photoperiod and temperature. This is possibly mediated through alterations in the endogenous growth regulators. Exogenous application of growth regulators also influence flowering. In the present study it was found that CCC 500 ppm caused the most advancement in flowering which gave the spike emergence 4.8 days after the spray (Fig.3). Advancement in flowering was pronounced in almost all the paclobutrazol treatments. Higher concentrations of CCC and CCC in combination with urea failed to produce the advancement effect in flowering compared to CCC 500 ppm. Advancement in flowering by CCC was earlier reported by many researchers (Bhattacharjee, 1983; Armitage, 1986; Murali and Gowda, 1988). Advanced flowering by the application of GA was also reported by Shanmugan *et al.* (1973) in chrysanthemum, El-Shafie *et al.* (1981) in carnation, Reddy and Sulladmath (1983) in china aster and Suma (1993) in gerbera. Present

study showed that application of 100 ppm GA caused much earlier spike emergence (Fig.3). Dahab *et al.* (1987) reported that acceleration of flowering by gibberellin application might be due to the role of gibberellin in reducing the apical dominance while Murti and Upreti (1995) suggested that exogenous application of growth regulators may influence flowering by retarding the vegetative growth. Earlier initiation of flowering in geranium reported by Armitage (1986) was explained as due to the inhibition of endogenous GA biosynthesis. But it cannot be applied here due to the flowering advancement shown by GA 100 ppm. Cathey (1964) reported that CCC may affect hormone balance in the plant. Armitage (1986) also suggested that accelerated flowering by CCC is complex and cannot be explained by a single cause. Perhaps increased carbon combined with a reduction in the GA level may be the reason for advanced flowering.

The absence of advanced flowering response by other GA containing treatments find an explanation in the report of Armitage (1986) that there may be an optimal GA level perhaps changing with the levels of other endogenous factors, for flower initiation to proceed. Additional factors such as other hormones and various metabolic activities may allow the optimal GA range to be met.

Advanced flowering in paclobutrazol treatment may be as a result of reduction in vegetative growth (Murti and Upreti, 1995) and partition of assimilates to contribute to the reproductive growth (Lever, 1986).

Influence on the emergence of the first spike after spray was not much pronounced in other treatments.

Eventhough CCC resulted in early flowering at 500 ppm concentration, it failed to produce a consistently similar effect in the number of days required for the appearance of the first floret in a spike. Eventhough there was a delay in the appearance of first floret in a spike by GA treatments with urea, later they caused advancement in floret appearance. CCC 500 ppm also showed some advancement in the later period (Table 8). On an average thoughout the study period (Table 12) appearance of the first floret occurred quickly in GA 100 ppm + 1% urea (12.8) followed by BA 100 ppm + 1% urea (13.0), while it was delayed in paclobutrazol 250 ppm with and without urea (21.2 and 19.6 days respectively) compared to 15.4 and 16 days in controls). Month effect was also significant and during March, April and May the floret appearance was much faster. While during the month of September the floret appearance was slower (Table 11). Quickest appearance in GA and BA treated plants may be attributed to better cell division and cell growth, while the varying effect in different months is due to the interaction of weather parameters. Faster floret appearance during March, April and May may be due to higher temperature during these periods (35.7°C, 35.2°C and 34.4°C) whereas the delay in time for the first floret appearance during September may be due to a relatively low day temperature (Table 8).

Regarding the time required for the opening of a floret, significant difference from controls were not noticed for most of the treatments except during March, April and May. During most of the months any of the paclobutrazol containing treatments resulted in earlier opening of the floret and on an average throughout the period paclobutrazol 500 ppm + 1% urea recorded minimum time for floret opening (2.8 days) while BA 200 ppm + 1% urea followed by GA 100 ppm + 1%

urea recorded maximum time (Table 12). Flower opening was quickest during January-February and is delayed during May and June (Table 11).

When time taken for the complete floret opening on an average is considered GA 200 ppm (22.5 days) recorded maximum time followed by BA 200 ppm + 1% urea (21.7). This character in turn is found to be related with the total number of florets produced in a spike. The more the number of florets produced more will be the time required for complete floret opening. Here paclobutrazol 250 ppm with and without urea (12.7 and 13.9 days respectively) recorded minimum time for complete floret opening. The number of florets opened on a day are generally two for all treatments during all the months.

In crossandra, spike yield and floret yield are the vitally important economic characters. Most of the yield parameters are related to each other. Number of spikes/plant is decided by the number of spikes produced in a month and the longevity of a spike in the field. Longevity of spike in the field in turn is affected by the time taken for the appearance of first floret, time taken for the opening of a floret, time required for the complete opening of florets in a spike and longevity of a floret in an intact spike.

When the total floret yield is considered, it was found to be decided by the total number of spikes produced, total number of florets produced in a spike and the spike length.

Results of the present study showed that almost all the floral characters and yield characters were enhanced or positively influenced by the bioregulators viz., GA 200 ppm and BA 200 ppm + 1% urea to the maximum.

Number of spikes produced in a month when considered, on an average for all the treatments maximum spike production per plant was noticed during June (10) (Table 12) and a minimum during March (2.8). A sudden release in the water stress by availability of rain after prolonged summer and other favourable climatic conditions (Appendix) may be the reason for more spike production. Slightly more spike production noticed in February may be due to favourable temperature conditions. Minimum spike production in March may be explained due to a high temperature and absence of rain for a prolonged period, whereas lesser spike production during September and October may be due to the fact that flowering has just started during that period and the plants had not began to show full potential.

When the treatments on an average were considered (Table 11) BA 200 ppm + 1% urea produced maximum number of spikes (8.8), followed by GA 200 ppm (7.7). BA 100 ppm and GA 100 ppm also performed better, the next being CCC 500 ppm. In support of the result obtained in the present study Richards and Wilkinson (1984) reported that the number of inflorescences were doubled in rose by BA. He suggests that BA changes the lateral buds to florel buds. Moreover the number of branches was more in BA treatment. Increase in the number of flowers by GA was reported earlier by Shanmugan *et al.* (1973) in chrysanthemum; Nanjan and Muthuswamy (1975) in Edward rose; Reddy (1978) in china aster and Datta *et al.* (1993) in *Chrysanthemum indicum*. In the case of CCC; only 500 ppm is found to be favourable for more spike production. Increase in the flower yield by CCC was also reported in china aster (Aswath *et al.*, 1994) and in *Jasminum multiflorum* (Murali and Gowda, 1988). But in contrast Shanmugan *et al.* (1973) and Shanmugan and Muthuswamy (1974) reported that CCC reduces flower yield. Secondary spike

production was also noticed by almost all the treatments except paclobutrazol, but the frequency was more in GA and BA containing treatments. Spike production was generally low for paclobutrazol treated plants throughout the period. But in contrast Lever (1986) reported that, as a result of paclobutrazol application higher number of lateral buds tend to become floral rather than vegetative with a consequent reduction in the number of lateral shoots and an increase in flower bud number. He suggested that there is a diversion of assimilates. There is an alteration of sink strength within the plant combined with reduction in vegetative growth, allowing greater partition of assimilates to contribute to the reproductive growth. But here the negative response may be due to a complete suppression of growth (Aswath *et al.*, 1994) and the very early application at higher dose might have caused a very poor sink strength. Nil production recorded in certain months may be due to unfavourable weather.

Regarding the total number of florets produced in a spike GA 200 ppm recorded maximum (45.4) on an average, followed by BA 200 ppm + 1% urea (43.2). Other GA containing treatments also recorded comparatively more number of florets in a spike. In general GA and BA containing treatments produced more number of florets in a spike. But in some concentrations and combinations (BA 100 ppm + 1% urea, GA 200 ppm + 1% urea) they failed to express the desirable character. The total number of florets produced in a spike showed significant variation pronounced during March, April and May. this variation may be due to the differential response of different treatments to the adverse weather (i.e. higher maximum temperature (35.7°C) and low rain). Eventhough response of most of the treatments were inconsistent, GA 200 ppm showed better response during April and May (51.5 and 44.5 respectively). During these months most of the treatments recorded poor performance compared to control (Table 13). In the case of

paclobutrazol treatments always there is lesser number of florets produced in a spike. Flowers in a spike are very compactly arranged, so that florets get damaged by the adjuscent spike.

Floret yields were found to be related with the number of spikes produced and number of florets per spike. GA 200 ppm and BA 200 ppm + 1% urea showed the maximum consistent positive influence almost throughout the year. Present study also revealed that even though there is a greater production of spikes during the month of June, the total floret yield was not increased to such an extent, which was due to the lesser number of florets/spike during this period. Khader *et al.* (1985) reported that in crossandra application of $ZnSO_4$ 0.5 per cent along with NPK and FYM resulted in higher yield. Similar effects could not be obtained here with any concentration or combination of $ZnSO_4$ in a consistent manner, which may be due to the lack of proper balance with other nutrients.

Sayed and Muthuswamy (1974) reported increased flower number in crossandra by growth retardants, MH, TIBA and Phosphon D. Among the growth retardants used in the present study, CCC 500 ppm recorded more floret yield during November to February of the year; but paclobutrazol showed a negative influence.

In loose flower trade, weight of flowers is an important character deciding the commercial value. Present study showed that, among the different bioregulators tried, GA containing treatments in general had more floret weight, expressed as weight of 100 florets (Table 19). Increase in fresh weight of flowers by GA_3 is reported in chrysanthemum (Dehale, 1993), which is similar to the result of the present study.

When floret dimensions, viz., length and diameter were considered, present study showed no consistent variation. Floret diameter was not significantly different in certain months and GA 100 ppm recorded comparatively more diameter during most periods of study. During certain months, the other GA containing treatments also showed similar results, which was in tune with the report by Dehale *et al.* (1993) in chrysanthemum. Increase in flower diameter by CCC (Ripka and Szanto, 1988; Aswath *et al.*, 1994) and paclobutrazol (Ripka and Szanto, 1988) was also reported in some other crops, while present study could not obtained similar results.

Length of the floret showed significant variation especially during the later period of study. GA and BA containing treatments in general was found to have the effect of increasing floret length during most of the months. Though the variation was not much pronounced, paclobutrazol during most of the months produced a negative effect on floret length. Cell elongation is one of the basic function of GA and an increase in flower size by GA 150 ppm was reported in marigold and aster (Lal and Mishra, 1986).

Total length of spike in crossandra, depend on the length of the portion bearing florets and the stalk length. In both cases significant variation was noticed among treatments (Tables 22 and 26). On an average treatments with BA 200 ppm + 1% urea (28.0 cm) and GA 200 ppm (24.3 cm) produced longer spikes followed by BA 200 ppm (22.9 cm), CCC 500 ppm + 1% urea (21.8 cm) and BA 100 ppm (21.6 cm) comparatively shortest spikes were produced by paclobutrazol containing treatments (Table 22). Similar results of reduced spike length by paclobutrazol was

also reported in Salvia (Mao *et al.*, 1991). In crossandra an increase in the spike length by $ZnSO_4$ 0.5% in combination with NPK and FYM was reported by Khader *et al.* (1985). In the present study $ZnSO_4$ 0.5% + 1% urea recorded more stalk length compared to other growth retardants.

Variation in the stalk length followed almost similar pattern as in the case of spike length except for $ZnSO_4$ 0.5% + 1% urea. More stalk length combined with lesser spike length suggest that floret bearing portion in the spike is shorter which resulted in lower number of florets per spike (Table 26).

Shorter spikes with shorter stalks were produced during May and June (11.8 cm and 12.6 cm spike length respectively), which may be due to the adverse climate conditions and slow growth.

BA 200 ppm + 1% urea recorded maximum stalk length almost throughout the year. Irrespective of the season stalk length was low for all paclobutrazol containing treatments and similar results were reported in gerbera by paclobutrazol and ancymidol (Lee and Lee, 1990). Increase in stalk length was also reported in chrysanthemum by GA (Datta *et al.*, 1993), which is almost similar in the present study.

Stouter spikes were produced by treatment with BA 200 ppm, BA 200 ppm + 1% urea and BA 100 ppm almost throughout the study period. Some paclobutrazol treatments also produced stouter spikes during certain months.

When flowers are excised from plants, the supply of water, nutrients and possibily some growth hormones also will be cut off (Mayak and Halevy, 1980). As a result the detereoration is much faster than those attached to plants under similar

condition (Hew and Wee, 1987). Even then there are various factors and conditions for controlling the rate of deterioration. In the present study, it was found that application of bioregulators in the field have no much influence on the postharvest characters of the cut spikes, whereas some other postharvest treatments may help in increasing their shelf life.

Analysis of two sets of data, one pertaining to pulsing (Table 27) and the other pertaining to precooling (Table 28) showed that variation in the fresh weight of the spike was not consistent as far as the bioregulator treatments were concerned, however, an increase in fresh weight of flowers by GA_3 in chrysanthemum (Dehale *et al.*, 1993) and a decrease in the fresh weight of china aster by the same chemical (Dahab *et al.*, 1987) was reported.

The commercial development stage of the flower at picking varies greatly in different flowers is influenced by season, environmental factors, distance to market etc. In many flowers cutting the flower at bud stage is recommended. But in crossandra, studies revealed that spikes cut when only the first floret just started opening failed to express better postharvest behaviour and a later stage with about 6-8 florets already opened was good. Similar results seen in gerbera was explained by Van Meeteren (1978) in such a way that the early cut flowers would not open properly which was related to the development of cavity in the centre of the stem which enables an alternate path way for water. But here lack of sufficient growth of the spike may be the reason.

In the case of pulsing significantly higher solution uptake was recorded for spikes produced from plants treated with paclobutrazol 250 ppm (1.3 ml) and BA 200 ppm (1.0 ml). But in the former entry of solution in the space between the

spikes as a result of its complete immersion in water owing to lower stalk length may be the reason for a higher solution uptake record. Among the different pulsing solutions pulsing with 10% sucrose + 500 ppm 8-HQ + 0.05% $AgNO_3$ resulted in maximum solution uptake and minimum by 10% sucrose + 500 ppm 8-HQ. Lal and Mishra (1986) reported that 8-HQC and $AgNO_3$ were best in improving flower quality and Burdett (1970) have suggested that the germicidal and bactericidal properties of the chemical substances have perhaps controlled the microbial growth and their by increased water conductivity. So in the present study maximum solution uptake might be due to $AgNO_3$. Solution absorption was found to be more when duration of pulsing is 24 hours, than pulsing for 12 hours.

Regarding the storage life of cut spike it was found that pulsing with 15% sucrose + 500 ppm 8-HQ combined with refrigerated storage in 300 guage polythene and 200 guage polythene resulted in a maximum of 162 hours storage life each. Vase life after a 72 hour period of storage was also found to be maximum in the above treatments (6 days). All the refrigerated storage conditions extended the storage life as well as subsequent vase life far more (1-6 days) compared to ambient condition storage. Similar results were reported by Halevy and Mayak (1981); Goszynska (1985) and Deambrogio and Garibaldi (1991). Among the ambient condition storage combination of pulsing with 15% sucrose + 500 ppm 8-HQ and storage in perforated cardboard box with wet newsprint gave better results with a maximum storage life of 62 hours. Incorporation of newsprint saturated with $KMnO_4$ solution in corrugated carton also gave better results than others. But use of activated charcoal did not give much positive response. Peles *et al.* (1977) also suggested the use of ethylene scrubbers like brominated charcoal or permanganate, their efficiency is doubtful because of the excessive amounts of the materials required to control the

ethylene level in storage. Battacharjee (1997) suggested that direct contact with $KMnO_4$ cause flower injury and so materials impregnated with $KMnO_4$ may be packed separately from flowers. But in contrast, here the contact with newsprint saturated and dried with $KMnO_4$ did not produced any flower injury, while the solid $KMnO_4$ and activated charcoal caused flower injury. The flower opening did not continue beyond a storage period of 72 hours under any of the ambient storage conditions and with any of the pulsing treatments.

With respect to pulsing, 15% sucrose + 8-HQ 500 ppm recorded maximum storage life (88 hours on an average) followed by 15% sucrose + 200 ppm $CoCl_2$ (63 hours) compared with 10% sucrose + 500 ppm 8-HQ and 10% sucrose + 200 ppm $CoCl_2$ (56 and 59 hours respectively). This reveals that higher concentrations of sucrose had a positive effect. The role of sugar in increasing postharvest life was reported by Woodson (1987), who also stated that reduced concentrations and increased pulse duration were not very effective. The results of different durations of pulsing also tally with the above finding that 12 hour pulsing was better compared to 24 hours. Bhattacharjee (1997) suggested that the main ingredient in pulsing solution is sugar and sucrose replaces the depleted endogenous carbohydrates utilized during the postharvest life of flowers. He also suggested that too low concentrations may not produce an optimal response, whereas excessive concentration may cause harmful effects. Role of HQ in prolonging postharvest life was also reported by Goszynska *et al.* (1985) and Deambrogio and Garibaldi (1991) and that of $CoCl_2$ by Kofranek and Halevy (1976) and Venkateswarayappa *et al.* (1981). Comparatively lower response to $AgNO_3$ was seen in the present study, in contrast with a better postharvest life by $AgNO_3$ as reported by Kofranek and Halevy (1976). They also suggested that $AgNO_3$ was relatively immobile in the

stems and stayed at the base without acting as ethylene antogonist, but probably as a bactericide.

Precooling was suggested as a pre-storage or pre- packing operation which removed the field heat and extended the storage life as reported by Halevy *et al* (1978); Bhattacharjee (1994) and Bhattacharjee (1997). But here in the present study similar effects could not be obtained.

In all the cases of pulsing, precooling and storage, after maximum storage period flowers could be kept in vase only for one or two days. But after 72 hours of storage it continued floret opening for more number of days in the case of refrigerated storage conditions. At the same time the colour and size of the florets were poor in later stages. In all the cases only two florets opened at a time, which reduced to only one on later stages of storage.

Crossandra is not populary used as a cut flower. Its vase life characters were not studied in detail. The effect of field application of certain bioregulators in the vase characters of crossandra along with different vase solutions are discussed here. The vase life of cut crossandra spikes immediately after harvest showed that among the bioregulator treatments in the field, spikes from BA 100 ppm treatment (Table 36) performed better which is in contrast to the report by Goyal and Gupta (1994) in rose.

In the present study GA 200 ppm expressed maximum fresh weight (2.45 g) followed by BA 200 ppm + 1% urea treatment. GA 300 ppm + 1% urea gave maximum solution absorption (Table 36) and minimum postharvest loss of weight by paclobutrazol 250 ppm treatment. Correlation between fresh weight and

solution absorption (correlation coefficient 0.151), fresh weight and vase life (correlation coeffcient 0.14) and fresh weight and postharvest loss of weight (correlation coefficient 0.469) were not significant. Similar was the case for solution absorption, postharvest loss of weight with vase life.

Among the different vase solutions maximum vase life was recorded in 3% sucrose + 100 ppm $CoCl_2$ (Table 37). It was in conformity with the result obtained by Venkatarayappa *et al.* (1981) in rose. They reported that Co^{2+} and sucrose had opposite effects on water uptake and water loss in that sucrose reduces both water uptake and water loss whereas Co^{2+} increased both. Both Co^{2+} and sucrose in combination improved the water balance of the cut flowers. Marousky (1969) reported that adequate moisture level can be maintained in cut roses provided conditions for sufficient water uptake or sufficient water retension or both are given. Minimum vase life was recorded in the control. Kaltaler and Stephonkus (1976) reported that the main effect of applied sugar in extending the vase life is by maintaining the mitochondrial structure and function. Increase in solution absorption by 3% sucrose + 200 ppm 8-HQ may be due to the reduction in physiological stem blockage by 8-HQ (Halevy and Mayak, 1981). The other treatments here were almost similar in behaviour to distilled water control, as far as solution absorption was concerned. Postharvest loss of weight was minimum in 3% sucrose + 100 ppm $CoCl_2$ treatment. Mayak *et al.* (1978) reported that sugar along with certain salts would help to maintain the osmotic concentration and turgidity there by reducing the postharvest loss of weight.

Interaction among different treatments showed that solution absorption was maximum for spikes from treatment GA 100 ppm + 1% urea and kept in 3%

sucrose + 200 ppm 8-HQ solution. Vase life recorded was maximum for $ZnSO_4$ 0.25% with or without urea in 3% sucrose + 100 ppm $CoCl_2$ and minimum for paclobutrazol 500 ppm kept in solution containing 3% sucrose +200 ppm 8-HQ + 50 ppm $AgNO_3$. Postharvest loss of weight recorded was minimum for spikes from paclobutrazol 250 ppm + 1% urea treatment, kept in 3% sucrose + 200 ppm 8-HQ + 50 ppm $AgNO_3$ solution. $AgNO_3$ failed to improve the postharvest behaviour in the present study which might be due to the fact that silver ion stayed at the base, without acting as an ethylene antagonist as suggested by Halevy and Kofranek (1977).

With respect to the yield parameters, the bioregulators namely GA 200 ppm and BA 200 ppm + 1% urea were found to be superior. Total spike yield and floret yield was maximum for BA 200 ppm + 1% urea. Superiority of GA 200 ppm in increasing the spike yield was noticed during October, February, April and June and of BA 200 ppm + 1% urea during September, November, March and May. Superiority of GA 200 ppm in floret production was noticed during November, March and May and of BA 200 ppm + 1% urea during September, October, December, April and June. Based on the results we can suggest that BA 200 ppm + 1% urea and GA 200 ppm may be useful for commercial application. Eventhough BA 200 ppm + 1% urea showed superiority in yield, GA 200 ppm may be adopted due to comparatively low cost.

The above two treatments were also found to have a highly significant influence in increasing the number of branches. In a popular cultivar like 'Delhi' where rooted cuttings are the only possible way of propagation, it is of added advantage that more number of propagules can be made available in a limited time through the use of GA 200 ppm or BA 200 ppm + 1% urea.

On the whole paclobutrazol showed a negative effect on vegetative and floral characters. This may be due to the higher concentrations applied at an early stage. Inspite of the negative effects, paclobutrazol helped in an early induction of flowering. Further studies are therefore essential to standardise the concentration and time of application which may help in obtaining plants with better appearance and desirable features.

Eventhough certain treatments extended the floret opening in cut crossandra spikes, the floret opening did not continue as in the case of a standing crop. Also the florets had a faded appearance and reduced size after harvest. Therefore, cutting of the spikes at an early stage is not advisable due to the considerable reduction in the floret yield. Therefore, from an economic point of view, the common practice of loose flower harvest itself is advisable compared to cutting the spike in an early stage for cut flower purpose.

Storage of the loose flowers in a refrigerated condition (polythene bags) increased the storage life upto three to four days as compared to one or two days in the ambient storage conditions. Studies may be undertaken in this aspect as to increase the storage life further under refrigerated condition along with the use of chemical treatments.

Summary

6. SUMMARY

Trials were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala from June 1996 to June 1997 to know the effect of bioregulators on growth, flowering and postharvest life of crossandra. Different bioregulators tried were GA, BA, Paclobutrazol, CCC and $ZnSO_4$, each at two levels either alone or in combination with 1% urea. Bioregulators were applied at bimonthly intervals from one month after planting. To extent the postharvest life of the cut spike pulsing and vase solutions containing sucrose, 8-HQ, $CoCl_2$ and $AgNO_3$ in different concentrations and combinations were tried. After pulsing, different storage containers viz., bamboo basket, corrugated carton, and perforated cardboard box and polythene bags in different thickness, were used for storage of flowers.

Bioregulators were found to have significant influence on the vegetative as well as floral characters of the plant. All the GA containing treatments, viz., GA 100 ppm and GA 200 ppm either alone or in combination with 1% urea increased the plant height, the maximum influence being shown by GA 200 ppm treatment. All the paclobutrazol containing treatments resulted in complete retardation of growth and negligible increase in height, almost throughout the study period.

Plant spread was also significantly increased by bioregulator treatments, the maximum being recorded for BA 200 ppm + 1% urea followed by GA 200 ppm while the paclobutrazol treatments registered minimum plant spread. Number of leaves produced was also maximum in BA 200 ppm + 1% urea, followed by GA

200 ppm and all the paclobutrazol treatments recorded considerably lower number of leaves.

Eventhough the variation in leaf length and width were not consistent, GA and BA containing treatments in general had a positive influence, while the paclobutrazol containing treatments recorded a notable negetive influence throughout the study period. But leaf area recorded was maximum for GA 100 ppm, GA 200 ppm, BA 100 ppm and BA 200 ppm + 1% urea, and the variation among the above listed treatments were inconsistent. Paclobutrazol containing treatments always recorded a lower leaf area. During most periods of the year leaf area recorded was maximum for BA 200 ppm + 1% urea.

Number of branches was also maximum for BA 200 ppm + 1% urea, followed by GA 200 ppm and lower number of branches were recorded for paclobutrazol treatments. Among the paclobutrazol treatments, branching was found to be the least for paclobutrazol 250 ppm at 12 months after planting.

GA 100 ppm + 1% urea, GA 200 ppm with and without 1% urea, BA 200 ppm with and without 1% urea showed more susceptibility to *Helicoverpa* incidence.

Emergence of the first spike after spray was found to be quickest in CCC 500 ppm, followed by paclobutrazol 1000 ppm + 1% urea while BA 100 ppm + 1% urea caused maximum delay.

After spike emergence, quickest appearance of the first floret was recorded for GA 100 ppm + 1% urea while maximum delay was in paclobutrazol 250 ppm + 1% urea treatment in general. Monthly variation in this character was

also significant and floret appearance was quickest during May and delayed maximum during September. Interaction among the months and treatments also showed much variation.

Maximum time for opening of a floret was recorded for $ZnSO_4$ 0.5% treatment during September while GA 100 ppm + 1% urea and BA 200 ppm + 1% urea recorded maximum time during most of the months. Floret opening was quickest in paclobutrazol 500 ppm + 1% urea followed by water sprayed control.

BA 200 ppm + 1% urea and GA 200 ppm treated spikes took maximum time for complete opening of the floret, and minimum time by paclobutrazol treatments especially paclobutrazol 250 ppm + 1% urea. Interaction with months were found to be significant so that GA 200 ppm during January recorded maximum time, where as paclobutrazol 250 ppm during April recorded minimum time.

Per plant spike production was found to be significantly higher with BA 200 ppm + 1% urea and GA 200 ppm treatments throughout the year. Paclobutrazol containing treatments always showed lower spike production throughout the study period.

Number of florets per spike as well as yield of florets per plant were also maximum for GA 200 ppm and BA 200 ppm + 1% urea and minimum for paclobutrazol containing treatments. During the month of February CCC 500 ppm produced maximum number of florets per plant, which recorded higher floret yield than most of the treatments. Among the paclobutrazol containing treatments those sprayed with 1000 ppm during the initial spray caused maximum reduction in the floret yield.

Monthly spike production, on an average was maximum during the month of June, while it was minimum during March. April and May also recorded lower spike production, and even nil production was noticed during these months. Eventhough month and treatment interaction were significant, BA 200 ppm + 1% urea and GA 200 ppm had more production throughout the period and minimum for paclobutrazol containing treatments. GA 100 ppm and CCC 500 ppm also recorded highest spike production during January and February respectively.

Regarding the weight of 100 florets, GA containing treatments in general recorded a higher weight throughout the study period, eventhough monthly difference in superiority among different concentrations and combinations of GA exist. All the paclobutrazol containing treatments recorded a lower weight through out the period of study.

Eventhough variation in the length of floret among the other treatments were not so consistent paclobutrazol treatments always recorded a lower floret length. Eventhough floret diameter is not significantly different compared to controls, GA and BA containing treatments in general recorded higher values.

Longevity of a floret in an intact spike showed no consistent variation and difference from controls were insignificant in most cases. But regarding the longevity of a spike in the field BA 100 ppm + 1% urea, and GA 200 ppm recorded maximum time. CCC containing treatments showed increased longevity especially during November, December and January. Paclobutrazol treatments in general and paclobutrazol 500 ppm + 1% urea in particular and $ZnSO_4$ 0.25% and 0.5% with and without urea recorded much lesser longevity.

Throughout the study period, BA 200 ppm + 1% urea recorded superiority in length of spike, followed by GA 200 ppm treatment. During the month of September CCC 1000 ppm + 1% urea recorded maximum length of spike. Remarkably low length of spikes were recorded for all the paclobutrazol containing treatments.

GA treatments, especially those with 1% urea showed a reduction in the spike diameter during most of the months, where as some BA containing treatments viz., BA 200 ppm with and without urea and paclobutrazol 500 ppm with and without urea recorded maximum diameter.

Stalk length during most of the periods showed superiority by BA 200 ppm + 1% urea, followed by GA 200 ppm. But during January GA 200 ppm and during June $ZnSO_4$ 0.5% + 1% urea recorded maximum stalk length. Paclobutrazol treatments caused a considerable reduction in stalk length and even stalkless spikes were produced during May and June.

With regard to pigmentation, CCC treatments viz. CCC 500 ppm, CCC 1000 ppm and CCC 1000 ppm + 1% urea recorded higher content of chlorophyll 'a' and paclobutrazol 500 ppm + 1% urea showed a higher content of chlorophyll 'b'. The latter treatment also recorded maximum content of chlorophyll 'a' + chlorophyll 'b'. Carotene content of flowers was maximum in CCC 500 ppm, followed by paclobutrazol 500 ppm and minimum for the two controls.

Harvest index for the spike to be used as cut flower was found to be the best when 6-8 florets already opened. In the case of pulsing/precooling and sotrage, pulsing with 15% sucrose + 500 ppm 8-HQ combined with refrigerated storage in

200 and 300 guage polythene bags recorded superiority. In general 15% sucrose + 500 ppm 8-HQ gave better effect on extending the storage life and vase life after storage. Precooling was found to have no effect on increasing the storage life and subsequent vase life. Bioregulator treatments in the field had no significant influence on the storage life and subsequent vase life. Other characters such as fresh weight, postharvest loss of weight and solution absorption had no significant correlation with postharvest life.

In the case of vase life without storage, BA 100 ppm recorded maximum, while 3% sucrose + 100 ppm $CoCl_2$ was found to be the best vase solution. When the interaction effect of solution and field treatments were considered $ZnSO_4$ 0.25% with and without 1% urea in 3% sucrose + 100 ppm $CoCl_2$ gave best result (upto 10 days vase life).Here also correlation with vase life and other characters as fresh weight, solution absorption and postharvest loss of weight were insignificant.

Total floret yield and spike yield were maximum in teatment with BA 200 ppm + 1% urea, followed by GA 200 ppm. So they may be useful for commercial application, of which GA is more adaptable due to comparatively low cost. Since rooted cuttings are the only propagating material in cultivar 'Delhi', increased branching obtained in the above two treatments help in providing more number of propagules in a limited period of time.

Inspite of the negative effects in vegetative and floral characters, paclobutrazol caused early flower induction. So standardisation of concentration and time of application may help in obtaining plants with better appearance and other desirable features.

Cutting of the spike at an early stage for cut flower purpose, will cause considerable reduction in the floret yield. So the existing practice of loose flower harvest is better. Also refrigerated storage extended postharvest life of loose flowers upto three or four days. So further studies may be undertaken to improve the postharvest life of loose flowers.

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*Originals not seen

APPENDIX

Weather data of Vellanikkara

	Temperature °C		Rainfall (mm)	RH 1 (%)	RH 2(%)	Sunshine (hrs)	Wind speed (hr)
	Max.	Min.					
1996							
June	30.5	23.8	400.3	94	75	4.7	3.0
July	28.8	23.1	588.7	96	83	2.7	2.7
August	29.1	23.6	310.0	95	78	3.7	3.0
September	29.2	23.7	391.6	94	74	4.3	2.7
October	30.1	22.9	219.3	93	70	6.0	2.0
November	31.5	23.6	22.1	84	59	7.1	3.7
December	30.5	21.8	60.4	80	55	6.8	6.4
1997							
January	32.0	22.9	0.0	78	45	9.6	6.9
February	33.9	21.8	0.0	82	39	9.3	3.9
March	35.7	24.0	0.0	82	37	9.6	4.0
April	35.2	24.5	8.2	83	50	9.6	3.3
May	34.4	24.5	63.0	87	57	6.7	3.3
June	31.2	23.0	720.5	93	71	65.9	2.7

EFFECT OF BIOREGULATORS ON GROWTH, FLOWERING AND POSTHARVEST LIFE OF CROSSANDRA *(Crossandra infundibuliformis* (L.) Nees.*)*

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ABSTRACT OF A THESIS

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ABSTRACT

Studies were carried out at College of Horticulture, Vellanikkara, Thrissur, Kerala from June 1996 to June 1997 to know the effect of bioregulators on growth, flowering and postharvest life of crossandra (*Crossandra infundibuliformis* (L.) Nees.).

All the GA containing treatments (GA 100 ppm, 200 ppm either alone or in combination with 1% urea) caused a significant increase in height, the most conspicuous one being GA 200 ppm. All the other vegetative growth parameters, viz., spreading habit, number of leaves, leaf area and number of branches were significantly increased by BA 200 ppm + 1% urea, followed by GA 200 ppm treatment.

Spike emergence after spray was earliest in CCC 500 ppm treated ones followed by paclobutrazol 1000 ppm + 1% urea treatments.

Month var variation was found to be prominent in most of the flowering and floral characters, along with their interaction with field treatments. In general GA containing treatments (GA 100 ppm + 1% urea) caused quickest floret appearance after spike emergence while this treatment and BA 200 ppm + 1% urea took maximum time for floret opening. Paclobutrazol 250 ppm + 1% urea showed maximum delay in floret appearance while paclobutrazol 500 ppm + urea caused quickest opening of florets.

BA 200 ppm + 1% urea and GA 200 ppm treatments were found to have maximum desirable influence on number of spikes produced, number of florets

per plant, number of florets in a spike, length of spike and stalk length of spike. Eventhough not much consistent and significant,CCC 500 ppm during October to January increased spike and floret yield.

Weight of florets had a slight positive influence by GA treatments, while length and diameter of the florets had no significant consistent variation among treatments.

Paclobutrazol containing treatments envisaged almost complete suppression of growth and flowering.

Chlorophyll 'a' content was maximum in CCC 500 ppm while chlorophyll 'b' and total of chlorophyll 'a' and chlorophyll 'b' were maximum in paclobutrazol 500 ppm + 1% urea treatment. CCC 500 ppm resulted in maximum carotene content of flowers.

Pulsing, precooling and storage behaviour was not influenced by field treatments, while pulsing with 15% sucrose + 500 ppm 8-HQ and storage under refrigerated conditions in 200 and 300 guage polythene covers was found superior for extending the storage life and other postharvest characters of crossandra spike.

Vase life without storage was maximum for BA 100 ppm treatment and 3% sucrose + 100 ppm $CoCl_2$ was found to be the best vase solution, while interaction effect cause $ZnSO_4$ 0.25% with and without urea to have the maximum vase life in the above solution.