REGULATION OF FLOWERING AND POST HARVEST BEHAVIOUR OF TUBEROSE (*Polianthes tuberosa* L.)

By

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled **"Regulation of flowering and post harvest behaviour of tuberose (*Polianthes tuberosa* L.)"** is a bonafide record of my research work done by me during the course of research and that the thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled **"Regulation of flowering and post harvest behaviour of tuberose (*Polianthes tuberosa* L.)"** is a record of research work done independently by Ms.Shiji K.Itty, 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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We, the undersigned members of the Advisory Committee of **Ms.Shiji K. Itty,** a candidate for the degree of **Master of Science in Horticulture**, with major in **pomology and floriculture**, agree that the thesis entitled **"Regulation of flowering and post harvest behaviour of tuberose (*Polianthes tuberosa* L.)"** may be submitted by Ms. Shiji K. Itty, in partial fulfilment of the requirement for the degree.

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Dedicated to my beloved

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INTRODUCTION

INTRODUCTION

Tuberose is one of the most important and widely acclaimed bulbous ornamentals of tropical and subtropical areas. It is extensively cultivated in different parts of the world, in countries like, France, Italy, South Africa and USA. Tuberose is commercially cultivated for cut flower purpose and also for the extraction of the highly valued natural flower oil. In India, it is largely produced in west Bengal, Karnataka, Andhra pradesh, Tamil Nadu, Maharashtra and Kerala. Thirty per cent of the flowers thus produced is used for religious purpose and offerings in temples, mainly in cities. Therefore growers and traders can earn much, by adopting improved techniques of tuberose cultivation. The severe beauty of the spikes, bright snow white flowers, sweetness of blooms, and delicacy of fragrance of this ornamental crop transform the entire area into a nectarine and joyous one.

The common tuberose (*Polianthes tuberosa* L.) are herbaceous perennials from Mexico introduced in the sixteenth century. "Polianthes", translated as "white or shining" is descriptive of attractive white flowers. 'Tuberosa" means "Tuber bearing". They are plants with short, thick rhizomes and thickened roots the cultivated tuberose is a complex assemblage of cultivars originated from complex ancestry of natural and artificial hybridization involving at least a dozen species in the family Amaryllidaceae. *Polianthes tuberosa* L.is the commercially cultivated species.

There are several varieties in tuberose named on the basis of number of petals, type of variegation on the flowers and leaves, colour and size of flowers etc. The most prominent cultivars are "Single", "Semi double", "Double" and "Pearl hydouble". These are assessed based on their flower quality and yield.

The heavy demand of tuberose necessitates the formulation of practices which will increase flower yield and post harvest life, while maintaining quality of spikes. Chemical regulation of plant growth has been a fascinating area of research.

The roles of certain bio regulators in increasing the yield of quality blooms have been proved beyond doubt. Different chemicals, displayed a remarkable diversity of effects.

The major areas where plant bio regulators are used in floriculture are plant propagation, plant height control, regulation of flowering and prolonging the life of cut blooms besides some other minor uses. Although growth regulators hold considerable potential of improving product efficiency and quality, there is a disinclination to use them. There are many overlapping and interacting effects of bio regulators in ornamental plants. The potential of tuberose in Kerala is still unexploited and a study was therefore taken up to asses the impact of bio regulators in tuberose.

The success of any cut flower industry, lies not only in the production of quality flowers, but in improving its keeping quality while retaining its beauty,

colour and shape also. This in turn has necessitated the evolution of technologies which ultimately will result in improved vase characters.

The present study was undertaken with a view of the given objectives.

1. To assess the influence of bio regulators on vegetative and floral characters.
2. To study the post harvest behaviour of tuberose flowers.
3. To standardize the pulsing and holding solutions for increasing the vase life of tuberose.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Synthetic growth regulating chemicals are becoming extremely important and valuable in commercial floriculture, for manipulating growth and flowering of many ornamental plants. Application of growth regulants can result in a broad range of morphological and physiological effects.

Tuberose is an important flower crop grown in many tropical parts of the world. The information regarding the role of bio regulators on tuberose are not many. This chapter attempts to review the literature pertaining to the effect of bio regulators on the growth and flowering of tuberose and also the post harvest life of tuberose spikes as influenced by some vase solutions.

2.1 Effect of bio regulators in tuberose

Ornamental crops find extensive use of bio regulators for modifying their developmental processes. The major areas where bio regulators played their roles in ornamental plants are in vegetative propagation, prevention of bud dormancy, growth control, promotion of flowering, prolonging the vase life of flowers and retarding senescence. In tuberose, generally GA is used for reducing plant height and increasing spike length. For getting an advanced flowering and good yield, cycocel was usually tried either as bulb treatment or foliar sprays. Prolonging the vase life of cut flowers has been a task of great importance to commercial growers, which was achieved by use of bio regulators and certain chemicals.

In a study conducted by Ramaswamy *et al.* (1977) on the influence of growth regulators on flowering and yield of tuberose, dormant tubers of *Polianthes tuberosa* were dipped for one hour in solutions of ethrel (ethephon) (50–5000 ppm), GA (50–400 ppm) or cyococel (chloromequat) (50-5000 ppm) and then planted. GA at 100 ppm or cycocel at 500 ppm advanced flowering by 17 and 15 days respectively. Flower yield was greatest when treated with cycocel at 1000 ppm.

Jana and Biswas (1979) studied the effect of growth substances on growth and flowering of tuberose in cv. Single. The plants were sprayed with GA_3 (10-1000 ppm) and B9 (diaminozide) (10–1000 ppm) at 4-5 leaf stage and 30 days later. Treatment with cycocel at 2000 ppm, B9 at 1000 ppm and GA_3 10 ppm produced maximum number of flowers per plant.

The effect of chloromequat on the growth and flowering of tuberose in autumn planting has been reported by Hassan and Agina (1980). In a two year trial with a local double flowered *Polianthes tuberosa* variety, the bulbs were planted in early September and the plants were sprayed with chloromequat at 1000, 2000 or 3000 ppm in early October. The treatment extended to the flowering period. Leaf dry weight, number of stalks and florets, fresh and dry weight of stalks and floret turgidity significantly increased with rising chloromequat rates.

Jana and Biswas (1982) soaked the rhizomes of *Polianthes tuberosa* cv. Single for 24 hours in solutions containing GA_3, B9 (diaminozide), CCC or ethrel at various concentrations. The fewest days to flower opening (97 days) occurred in

plants treated with 10 ppm GA_3 and the highest number of flowers per spike (35.5) was on plants treated with 1000 ppm B9.

In another trial in tuberose, Biswas *et al.* (1983) GA_3 (10-1000 mg l^{-1}), CCC (chloromequat) (0.02-2 mg l^{-1}) ethrel (ethephon) (0.025-2.5 mg l^{-1}) or IAA (10-1000 mg l^{-1}) by soaking the rhizomes for 24 hours or applying 30 days after sprouting and again 20 days later. It was found that leaf emergence was earliest (11 days) in rhizomes treated with IAA at 10 mg l^{-1} and flowering was earliest (87 days) in rhizomes treated with IAA at 10 mg l^{-1} and CCC at 2 ml l^{-1} and the highest number of flowers per spike (46) was on plants sprayed with GA_3 at 100 mg l^{-1}.

In tuberose (*Polianthes tuberosa)* CCC (500-1500 ppm) increased the number of flowering spikes and flower number as compared to control (Stephenson, 1985).

Choudhary (1987) observed that MH decreased plant height while GA_3 at 50-150 ppm and CCC at 500-1500 ppm increased plant height and number of leaves per plant. Ethrel reduced flowering period and increased rhizome production per plant. All treated plants had an increased number of flower spikes and flower number than control plants and number of flowers was more for CCC 50 ppm.

Parmar *et al.* (1993) reported that pre planting dip of tuberose bulbs in BA and GA solutions delayed the sprouting. Earliest sprouting was reported and plant attained maximum height at flowering in water soaking treatment. The GA treated bulbs produced tallest plants with more height, fresh weight and number of

sprouts per clump. Treating with BA and GA treatment resulted in more number of spikes. Treating bulbs with BA, GA, tap water and thiourea significantly increased the fresh weight of florets as compared to control. Significantly higher flower length was recorded in BA, GA and thiourea treated bulbs.

Preeti *et al.* (1997) studied the effect of pre plant treatment of bulbs, on growth and flowering of tuberose and showed that treatment of bulbs with GA_3, ethrel and thiourea promoted the early appearance of flower spikes and number of flower spikes but decreased the number of bulbs produced per plant.

Effect of growth substances on flowering and shelf life of tuberose was studied by Reddy *et al.* (1997). Plants treated with GA were early to flower, while those treated with BA were late to complete their first flowering but increased spike length. Application of CCC reduced the spike length and resulted in more number of spikes per plant. Highest flower yield was obtained with 1500 ppm CCC. Vase life was the longest, for flowers from BA treated plants.

Devendra *et al.* (1999) studied the effect of bio regulators, viz., cycocel, GA_3 and ethrel on growth and flower yield of tuberose, revealing that GA_3 at 200 ppm enhanced bulb sprouting and plant height while cycocel and ethrel significantly reduced plant height, the shortest being recorded with foliar application of 4000 ppm cycocel. The shelf life of cut flowers and clump weight was greater with 4000 ppm cycocel.

Manohar (2000) explained the effect of different bio regulators viz., IAA, GA_3 and ethrel on growth and flowering of tuberose. Results revealed that

GA_3 produced maximum number of leaves, number of florets per spike and increased the longevity of individual floret on a spike whereas IAA enhanced the vase life of the spike.

2.2 Bio regulators in other bulbous ornamentals

Several studies have shown that the height of plants was influenced by application of growth retarding chemicals Bhattacharjee *et al.* (1974) studied the interaction of auxin and gibberellin with growth retardants on growth and flowering of *Dahlia variabilis*. Application of CCC and Alar each at 5000 ppm either alone or in various combinations in dahlia cv. 'Masterpiece' resulted in suppressed height with Alar where as CCC had little effect.

The effect of soil drench application of CCC (chloromequat), B9 (diaminozide), ethrel, IAA, GA3 and NAA at different concentrations was studied on growth and flowering of gladiolus cv. Friendship (Bhattacharjee, 1984). GA at 10 and 100 ppm increased flower stalk, rachis length, floret size, number per spike and lengthened the life of the spike. Marked improvement in flowering was obtained with 100 ppm IAA. Application of CCC, B9 and ethrel generally increased flower size and IAA, GA_3 and NAA at 10 and 100 ppm increased the number of flowers per spike. GA_3 at 10 and 100 ppm increased vegetative growth. Spraying three times with GA_3 100 ppm increased plant height and the number of leaves in gladiolus. GA_3 at 50, 100 or 200 ppm improved spike quality in terms of number and size of flowers. In most cases concentration of 100 ppm applied 3 times was the most effective spray treatment.

The influence of paclobutrazol on the growth and flowering of pot grown gladiolus was studied by Hwang *et al.* (1986) in the cvs. 'Spic and Span' and 'Hunting Song'. Paclobutrazol was applied at the two leaf or four leaf stage, either as a soil drench at 0-15 mg/15 cm diameter pots or as a foliar spray at 0-100 ppm. The results indicated that the plant height for 'Hunting Song' was reduced more by treatments at the two leaf stage than at the four leaf stage, while 'Spic and Span' showed no difference in response. Soil application at the highest concentration produced the shortest plants.

Attempts were made to compare the influence of ethylene producing substances with that of cultar in dahlia. The cultar treatment reduced stem height by 50 per cent when compared to control and it continued its inhibitory action for two years. Cultar is very good substance for obtaining dwarfed form and therefore good for pot bedding culture (Rounkova, 1989).

Ravidas (1990) reported the effect of GA on spike length. Application of GA at 50 ppm was superior in increasing the spike length, number of florets per spike and the longevity of individual florets in gladiolus.

The miniature gladiolii named 'Orchidiola' could constitute attractive flowering plants when dwarfed successfully using paclobutrazol (Barzilay *et al.*, 1992). The trials were conducted in cvs. 'Adi' and 'Kinnert' where paclobutrazol was applied either as corm dipping, drenching the growth medium or as foliar spray. The desirable height reduction was obtained by drenching at 10-20 mg/pot. However, at this level, the percentage of flowering was reduced.

According to Mahesh and Misra (1993) BA (50 ppm) increased the number of shoots per corm from 2.05 to 2.28, IAA (100 ppm) increased total leaf area (3.22 to 4.57 cm) GA_3 (200 ppm) and BA (50 ppm) increased the plant height from 87.39 to 90.57 and 91.94 cm, respectively. GA_3 (1000 ppm) and IAA (250 ppm) increased the number of florets per spike from 10.19 to 10.66. The flowering duration of each spike was increased by all except BA (25 ppm). But the spike length was reduced in all except BA and IAA (50 and 250 ppm). The rachis length was reduced by all the treatments in gladiolus.

Mohanty *et al.* (1994) studied the effect of pre planting chemical treatment of corms on growth and flowering of gladiolus. Various concentrations of GA_3 and ethrel were used. Results showed that all concentrations of GA_3 increased plant height while ethrel had little effect on growth parameters.

Gopinath (1997) conducted a study to ascertain the effect of corm size and growth regulators on the vegetative and floral characters of gladiolus 'Friendship' which revealed that GA and ethrel enhanced the sprout emergence. Paclobutrazol resulted in significantly dwarf plants and was found to be inferior with regard to flowering and corm characters.

Efficacy of ancimidol, paclobutrazol and uniconazole on growth of tuberous rooted dahlia was studied by Whipker and Hammer (1997). All the plant growth regulators at all doses reduced total height of the plant by 21 per cent when compared with the control.

Pal *et al.* (1998) in a trial with GA, BA and ethrel on gladiolus revealed that corms treated with BA induced early sprouting (7 days) when compared with water (57 days) for 24 hours. Ethrel at 100 ppm increased leaf area and induced early appearance of flower spikes and also resulted in more florets per spike.

2.3 Keeping quality in tuberose

The extension of cut flower vase life and improved post harvest development and maintenance has now become economically important practice based on scientific principles. Accomplishment of the extension of vase life depends on post harvest cut flower handling and a preservative solution for ensuring an ample supply of water with metabolites and regulatory substance to petals and leaves. This has led to a growing interest in extending the post harvest life of cut flowers by attracting increasing number of researchers investigating both basic and applied aspects of flower life and flower opening.

Pathak *et al.* (1979) studied the effect of Dettol (0.1 and 0.7%), 8 HQ (0.001 and 0.003%), GA (0.01 and 0.03%) and Sucrose (10 and 20 %) and revealed that sugars and hormones are most effective inducers of bud growth and development and also increased vase life of buds in tuberose.

Application of sucrose, citric acid, aluminium sulphate and copper sulphate in the holding solution for tuberose was studied by Mukhopadyay (1982) and found out that sucrose and citric acid significantly promoted the vase life of tuberose.

In a study conducted by Kondakar and Mazumdar (1985) thirty centimeter long cut flowers of tuberose (*Polianthes tuberosa)* were held on eight different preservative solutions for up to 96 hours. The best results were obtained with 3 per cent sucrose + 0.03 per cent hydroxy quinoline citrate + 0.01 per cent $AgNO_3$.

According to Balakrishna *et al.* (1989) when spikes of tuberose with one or two of the lower florets open, cut to 55 cm and placed in a bottle containing 300 ml distilled water, chloride or sulphate of aluminium, calcium and magnesium (0.5 or 1.5) or cobalt sulphate (1, 1.5 or 2 μm) resulted in increased, cumulative water by all the salt uptake and reduced the water loss to water uptake ratio. Vase life was increased by all the treatments compared with control (7 days). The longest vase life was observed in 1 mM aluminium (10.63 days) followed by 2 mM cobalt (10.40 days).

Naidu and Reid (1989) explained the post harvest handling of tuberose. A sugar containing vase preservative 1.5 per cent and/or pre-treatment with sugar (20 per cent sucrose for 15-20 h) improved display life of the stem before or after storage. The presence of open flowers on the spikes increased solution uptake and response to the sucrose pulse.

Gowda (1990) kept cut *Polianthes tuberosa* spikes in solutions containing 1 or 2 per cent sucrose and/or aluminium sulphate at 200 or 400 ppm and held for upto 12 days. He found that vase life was longest (12 days) in 1 per

cent sucrose + 200 ppm aluminium sulphate and 2 per cent sucrose + 400 ppm aluminium sulphate.

Das and Burman (1990) placed freshly cut spikes of a single flowered cultivar of tuberose in glass jars containing 500 ml sucrose, B-9 (diaminozide) silver nitrate, copper sulphate, boric acid, MH or aluminium sulphate solutions all at 0.2 or 0.4 per cent. Control spikes were placed in water. The solutions was changed every 3 days. Longest vase life (12.6 days) was obtained with 0.4 per cent sucrose solution. All the solutions increased vase life compared with the control (6.1 days). The highest percentage of fully opened flowers (79.2%) was obtained in 0.4 per cent MH solution compared with 58.9 per cent in the control.

Cut *Polianthes tuberosa* cv. Chapeada flowers with 80 cm long stem and 4 pairs of leaves were held in tap water (control) or in various solutions containing combinations of sucrose (3%) citric acid (200 mgl-^{1}), $AgNO_3$ (600 mg l^{-1}), HQC (200 mg l^{-1}), cycocel (30 mg l^{-1}), TIBA (200 mg l^{-1}). Water uptake was greatest in control throughout the experiment. Fresh weight was greatest in control and sucrose + HQC. Significantly highest number of open flowers were recorded in the control than in other treatments on days 4, 6 and 12 but the control treatment also hastened flower senescence (Alverz *et al.*, 1994).

Gawade *et al.* (1994) pulsed the cut flower stalk of *Polianthes tuberosa* with 5, 10, 15 and 20 per cent sucrose for 2, 4, and 6 hours and then kept in tap water which was changed everyday and the flower stalk shortened by 1.5 cm. Vase

life was 7 days. Stalk fresh weight was generally highest in tap water control. Pulsing for 2 hours tend to increase flower opening.

Murthy and Gowda (1994) studied the role of pre emergence herbicides viz., alachlor, diuron, pendimethalin, atrazine, butachlor, 2,4-D and metachlor on the life of cut tuberose flowers. Spikes were harvested when 1-2 lower most florets had opened and were placed in 2 per cent sucrose solution. Fresh weight of the flower spike was not affected by herbicidal application. There was no significant difference in spike weight or vase life as compared to control.

Saini *et al.* (1994) while studying the effect of some chemicals on the vase life of tuberose cv. Single. reported that solutions of $AgNO_3$ or sucrose increased vase life of *Polianthes tuberosa* flowers when compared with control (distilled water).

Katwate *et al.* (1995) explained the influence of low temperature storage on the longevity of cut spikes of tuberose. Results indicated that vase life was longest with low temperature storage for 48 hours.

Reddy *et al.* (1995) found that tuberose flowers in a solution containing citric acid (100 ppm), 8 HQS (400 ppm) and sucrose (4%) lasted for 16 days. Water uptake and retention were also improved by this solutions (8 days).

In another experiment Reddy *et al.* (1995) explained that the vase life of tuberose flowers was influenced by 8 HQS (200 or 400 ppm) and sucrose (4%) where a vase life of 13.7 days was reported, while in control the flowers lasted

only for 8-7 days. This efficiency of 8 HQS in prolonging vase life was due to increased water uptake.

In order to standardize the concentration and duration of sucrose pulsing and to assess the efficiency of impregnation treatments with $AgNO_3$, a study was conducted in tuberose by De *et al.* (1996) which indicated that 20 per cent sucrose pulsing improved floret opening, floret diameter, water uptake, longevity of the floret and vase life.

Reddy *et al.* (1996) in a trial showed that cobalt along with sucrose enhanced the vase life of *Polianthes tuberosa* flower spikes by increasing water uptake, maintaining the water balance and maintaining higher weight throughout the vase period.

Reddy *et al.* (1997) in another study on the influence of 8 HQS and sucrose on the post harvest quality of tuberose proved that sucrose, 8 HQS alone and their combinations significantly enhanced the vase life of tuberose flowers to 11.7 days when compared with control (5 days).

Further studies by Reddy *et al.* (1997) on improving the post harvest life of tuberose with chemicals like citric acid, 8 HQS, cobalt, nickel etc. revealed that cut flower spikes of *Polianthes tuberosa* kept on 4 per cent sucrose + 8 HQS or citric acid + cobalt exhibited best water balance. Highest numbers of opened and fully opened florets were observed in 4 per cent sucrose + cobalt and 8 HQS. The highest vase life of 12.33 days was observed in 4 per cent sucrose + 8 HQS + Nickel.

Studies on flowering and shelf life of flowers of tuberose cv. Double as influenced by growth substances showed that plants treated with GA, BA and phosphon increased spike length, while application of CCC and B-9 reduced spike length. Highest flower yield was obtained with application of 1500 ppm CCC or B-9. Vase life was longest (7.67 days) for flowers from BA treated plants (Reddy *et al.*, 1997).

Bhaskar and Rao (1998) conducted a trial to study the effect of BA, GA, NAA and MH at concentrations of 50, or 100 on the vase life of cut tuberose spikes and proved that BA and GA at 100 ppm were the most effective in improving the water uptake, maintaining a better water balance and thereby increasing the fresh weight of flowers which finally contributed to increased number of florets opened per spike (61.73 and 56.89%). By adding 100 ppm BA to vase water petal senescence was delayed and the freshness was maintained for a longer time than 100 ppm GA.

Experiments were conducted by De and Burman (1998) to study the effects of various chemicals on the post harvest life and quality of cut tuberose flowers. Boric acid (250 ppm), $Al_2(SO_4)_3$ (50 ppm), $CaCl_2$ (1000 ppm), $AgNO_3$ (50 ppm), $CoCl_2$ (25 ppm) and citric acid (400 ppm) were found beneficial for improving floret opening, flower diameter and vase life.

De and Burman (1998) harvested spikes with a stem length of 75 cm and creamy white buds or one floret opened and used 8 per cent sucrose as the holding solution produced the highest quality, longest lasting tuberose cut flowers.

Nagaraja and Gowda (1998) soaked the bulbs of tuberose in BA, ethrel and GA_3 (all at 100, 500, 1000 & 1500 ppm) for 24 hours and then planted. Fresh weight was increased with all concentration of ethrel and GA_3 compared with the control. But fresh weight of those treated with BA was less than that of control. All the treatments significantly increased the vase life. The maximum vase life of 8.66 days was produced by BA 1000 ppm compared with 6.33 days in control.

Reddy *et al.* (1998) in a trial discussed the importance of $AgNO_3$ in improving the vase life of cut tuberose spikes. Spikes kept in distilled water lasted for 11 days while spikes kept in Silver solution lasted for 6.6 days. $AgNO_3$ decreased water uptake and increased ratio of water loss to H_2O uptake accelerating the fresh weight loss of the spikes.

Devendra and Nagda (1999) studied the effect of growth regulators on growth and flower yield of tuberose. Plants were treated with GA, cycocel and ethrel as bulb dip and foliar application. Chloromequat and ethrel reduced the plant height significantly when compared to GA. Foliar application of GA increased flower spike length and flower diameter. Clump weight and shelf life of cut flowers were greatest (427.3 g and 14.06 days) with 4000 ppm chloromequat bulb treatment.

Vijayabhaskar *et al.* (1999) studied the effect of minerals on post harvest life of cut tuberose cv. Double. Calcium nitrate, aluminium sulphate, borax, and silver nitrate were tried at two concentrations 0.01 and 0.05 per cent. Result revealed that aluminium sulphate and calcium nitrate 0.05 per cent increased vase life as well as floret opening. These mineral salts exerted a dual

effect in delaying the senescence of cut tuberoses by increasing the uptake of water which is caused by the ions of aluminium and calcium.

Effect of sucrose on bud opening and vase life of tuberose was studied by Singh and Arora (2000). The opening of buds was considerably improved with vase solution containing sucrose and 8 HQC. Sucrose 3 per cent was found to be effective for cv. Double.

A series of experiments were conducted with different minerals, plant growth regulators and organic acids in preservative solution for cut tuberose. From these, calcium nitrate, benzyl adenine, citric acid and a combination of these treatments with and without sucrose was tried to develop a viable and cost effective preservative solution for extending vase life of cut tuberose spikes. Calcium nitrate 0.01 per cent + citric acid 250 ppm + sucrose 3 per cent combination proved to be the best for recording maximum vase life of 14.67 days (Vijayabhasker *et al.*, 2000).

2.4 Keeping quality of flowers in other bulbous ornamentals

Kofranek and Halevy (1976) pulsed gladiolus stems at 21°C with 20 per cent sucrose in combination with $AgNO_3$ 7 or 10 days prior to storage resulted in greater floret opening and size than those not pulsed. The silver treatment alone was not effective. Sucrose fulfills the requirements for a CHO source and osmoticum which are necessary for floret growth and development. Therefore treatment with sucrose prior to shipping or storage of gladiolus is recommended for long periods.

According to Nunes (1989) post harvest losses in cut gladiolus sometimes rise to 50 per cent due to poor transport and inefficient storage. To minimize these losses 1-2 m spikes were held in several solutions containing 40 ppm potassium nitrate, 60 ppm GA, 40 ppm magnesium sulphate or distilled water. The best results were obtained in distilled water which gave a vase life of 15 days.

Gowda (1990) studied the effect of calcium, aluminium and sucrose on vase life of gladiolus. Longest vase life (18.3 days) was with 1.0 mM aluminium sulphate followed by 3 per cent sucrose (17 days) and 2 per cent sucrose (15.3 days). Shortest vase life (9.1 days) was in the control. It was suggested that the increase in vase life with aluminium sulphate may be due to lowering of petal pH, stabilization of anthocyanins, acidification of the holding water thus reducing bacterial growth and improving water uptake. The increase in vase life due to sucrose may result from decreased moisture stress and improved water balance.

Lal *et al.* (1990) studied the effect of HQS, HQC, $AgNO_3$ and sucrose on the vase life of gladiolus. Results revealed that the longest vase life was given by $AgNO_3$ at 3000 ppm and HQC at 200 ppm. The best flower quality was retained with HQS, HQC and $AgNO_3$.

Murali *et al.* (1991) studied the post harvest physiology of gladiolus flowers as influenced by cobalt and sucrose. Gladioli spikes were harvested and placed in 2 or 4 per cent sucrose, 2.5 and 5 mM cobalt. Sucrose and cobalt alone or

in combination increased water uptake and transpirational loss and increased the fresh weight of the spikes when compared with control.

Nagarajaiah and Reddy (1991) in a trial kept cut roses in 2 mM $CaCl_2$, 0.25 mM $ZnCl_2$ with or without 2 per cent or 4 per cent sucrose. Both water uptake and water loss over a 6 day period were reduced by sucrose and increased by metal salts alone or in combination with sucrose. All treatments resulted in a reduced water loss the water uptake ratio being most effective with 0.25 mm $ZnCl_2$ + 4 per cent sucrose followed by 2 mM $CaCl_2$ + 2 per cent sucrose. All treatments increased vase life and fresh weight of cut roses.

Scholten *et al.* (1991) in a study on post harvest of gerbera cut flowers discussed the importance of harvesting at the right stage of flower maturity, handling, water quality and packing in maintaining post harvest quality of the flowers.

In another experiment Murali and Reddy (1993) studied the influence of sucrose and metal salts on the post harvest life of gladiolus using aqueous solutions of different metal salts and sucrose. A maximum vase life of 12 days was recorded with sucrose + cobalt compared with control (7 days).

Improvement of the keeping quality of gladiolii spikes by sucrose pulsing was studied by Meir *et al.* (1995). Pulsing of gladioli spikes with sucrose 10 per cent prior to packaging retarded the bract yellowing and improved flower quality and opening of the florets.

In a trial conducted by Patil and Singh (1995) the longest vase life of cut rose cv. Gladiator was reported with combination solution of aluminium sulphate, sucrose and citric acid (7.23 days) when compared with control (5.33 days).

Serek *et al.* (1995) explained the physiology of flower senescence in gladiolus. Treatment with STS increased the flower opening to about the same extent as treatment with 1 per cent sucrose.

Seeman and Huber (1995) showed that spike weight, water uptake, percentage of open flowers and delay in senescence of gladiolus flowers was more with spikes pulsed in 10 per cent sucrose. There was no significant difference between 12 and 24 hour treatment.

Zhou *et al.* (1995) proved that maximum vase life of 12 days in gladiolus was recorded when the spikes were treated with a combination solution of sucrose, $AgNO_3$ and 8 HQS.

The effect of various vase solutions on the post harvest life and quality of gladiolus spikes was studied by De *et al.* (1996). Sucrose 4 per cent + 8 HQC 250 ppm was the best pulsing treatment for improving the post harvest life and quality of gladiolus spike.

De *et al.* (1996), conducted a series of experiments on pulsing and in gladiolii spikes in order to standardize the concentration and duration of sucrose pulsing and to assess the efficiency of impregnation treatments with $AgNO_3$. Impregnating cut 'Dhanvantari' spikes with $AgNO_3$ at 1000 ppm for

10 minutes before pulsing with 20 per cent sucrose for 16 h had the most beneficial effect on post harvest life and flower quality.

Suneetha and Kumar (1998) proved that longest vase life of 13.44 days was observed with 5 per cent sucrose and 600 mg 8 HQC when applied in combination in the case of the gladiolus spikes as preservative solution.

MATERIALS AND METHODS

MATERIALS AND METHODS

Experiments on regulation of flowering and post harvest behaviour of tuberose cv. Double were carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur during 1998-2000. The study was conducted to assess the influence of bio regulators on vegetative and floral characters. and to standardize the pulsing and holding treatments for improving post harvest life of tuberose.

3.1 Planting materials

The experiment was laid out at the college of Horticulture, Vellanikkara. Uniform sized bulbs (1.0 – 1.5 cm diameter) of tuberose cv. Double were used. Bulbs were planted after treating with carbendazim 0.1 per cent for half an hour to avoid fungal attack and stored for 3 weeks before planting, to overcome dormancy.

3.2 Season

Planting was done during July-August in the year 1998-2000.

3.3 Method of planting

Site receiving plenty of sunlight was selected and it was ploughed and levelled. Measures were taken to make the land free from perennial weeds. Raised beds of uniform size were taken giving a spacing of 50 cm in between the beds. FYM was applied @ 2 kg m^{-2} at the time of planting. Diuron was given as a pre emergent weedicide. The bulbs were dipped in 0.1 per cent carbendazim for half an

Plate 1. General view of the experimental field

Plate 2. General view of the experimental field

Plate 1

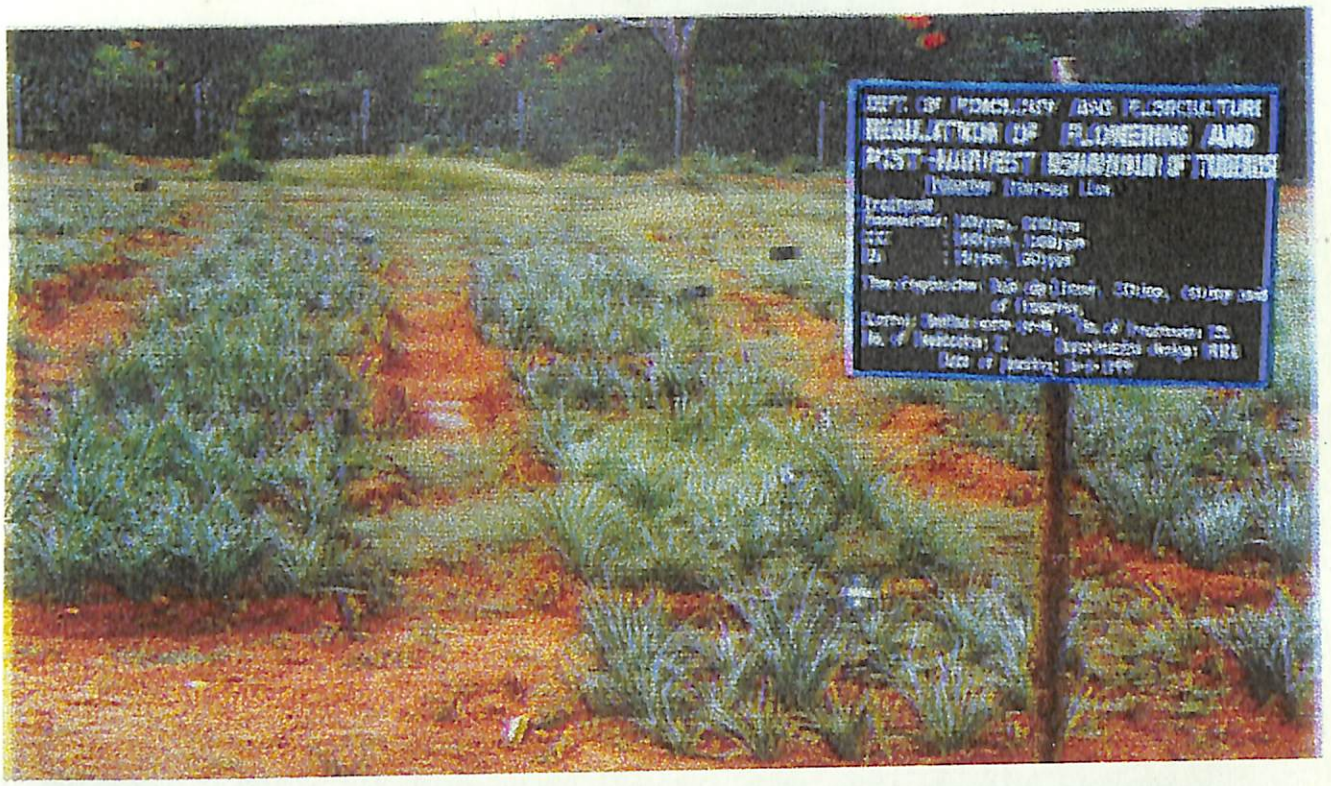


Plate 2

hour just before planting and then planted on beds at a spacing of 25 x 25 cm after giving the particular treatment.

3.4 General management

The field was irrigated just before planting to facilitate sprouting. The plants were watered once daily during summer season. Weeding was done manually every month. Earthing up was also done after 2 months along with the application of chemical fertilizers as per the package of practices recommendation of KAU (KAU, 1996).

3.5 Lay out of experiment

Experimental design followed was RBD with two replications. Twenty five plants were planted in a bed for each treatment. There were 24 different treatments along with a control. Each replication had 625 plants. Vegetative growth was measured by taking observation from five plants on each bed. Three spikes from each bed were taken to the laboratory when first pair of florets fully opened for conducting vase life studies.

3.6 Field experiments

The various treatments were as follows

T_1	-	Paclobutrazol 100	ppm	Bulb dip
T_2	-	Paclobutrazol 200	ppm	Bulb dip
T_3	-	Paclobutrazol 100	ppm	30 DAP
T_4	-	Paclobutrazol 200	ppm	30 DAP
T_5	-	Paclobutrazol 100	ppm	60 DAP
T_6	-	Paclobutrazol 200	ppm	60 DAP
T_7	-	Paclobutrazol 100	ppm	at Flowering
T_8	-	Paclobutrazol 200	ppm	at Flowering

T_9	-	CCC	500	ppm	Bulb dip
T_{10}	-	CCC	1000	ppm	Bulb dip
T_{11}	-	CCC	500	ppm	30 DAP
T_{12}	-	CCC	1000	ppm	30 DAP
T_{13}	-	CCC	500	ppm	60 DAP
T_{14}	-	CCC	1000	ppm	60 DAP
T_{15}	-	CCC	500	ppm	at Flowering
T_{16}	-	CCC	1000	ppm	at Flowering
T_{17}	-	BA	500	ppm	Bulb dip
T_{18}	-	BA	100	ppm	Bulb dip
T_{19}	-	BA	50	ppm	30 DAP
T_{20}	-	BA	100	ppm	30 DAP
T_{21}	-	BA	50	ppm	60 DAP
T_{22}	-	BA	100	ppm	60 DAP
T_{23}	-	BA	50	ppm	at Flowering
T_{24}	-	BA	100	ppm	at Flowering
T_{25}	-	Control			

In bulb dip treatment, the bulbs were soaked for one hour in the bio regulators before planting. Foliar sprays were given thrice, i.e., 30 days after planting, 60 days after planting and at flowering.

3.6 Observations

The following observations were recorded during the course of experiment.

3.6.1 Pre harvest studies

3.6.1.1 Vegetative characters

The following vegetative characters of plants under each treatment were recorded.

3.6.1.1.1 Days to sprouting

Days taken for the bulbs to sprout was noted.

3.6.1.1.2 Percentage of sprouting

The number of bulbs sprouted in each plot was recorded and the percentage of sprouting was worked out as

$$\frac{\text{Number of bulbs sprouted}}{\text{Total number of bulbs}} \times 100$$

3.6.1.1.3 Plant height

The height of the plant was measured from base to the top of the shoot at monthly intervals and expressed in centimeters.

3.6.1.1.4 Plant spread

The spread of the plant in East – West and North – South directions were recorded at monthly intervals and expressed in centimeters.

3.6.1.1.5 Number of leaves

The total number of leaves present on the plant was counted at monthly intervals and recorded.

3.6.1.1.6 Length of leaf

Length of the leaf was measured from the bottom to the top of the leaf and expressed in centimeters.

3.6.1.1.7 Breadth of leaf

Breadth in the middle portion of the leaf was taken as breadth of the leaf and expressed in centimeters.

3.6.1.1.8 Total leaf area

Leaf area was measured using the leaf area meter and were multiplied with the total number of leaves to get the total leaf area and given in centimeter square.

3.6.1.1.9 Number of plants per hill

Number of plants produced from one bulb was recorded at monthly intervals.

3.6.1.2 Floral characters

3.6.1.2.1 Days to first spike emergence

Number of days taken from planting to the emergence of spike was observed and recorded.

3.6.1.2.2 Days to first floret opening

Time taken (days) for the opening of the first floret in each spike was noted and recorded.

3.6.1.2.3 Days to complete opening of florets

Number of days taken for the complete opening of the florets of each spike in the field was recorded.

3.6.1.2.4 Length of the spike

Length of each spike was measured from the base to tip of the inflorescence and expressed in centimeters.

3.6.1.2.5 Girth of the spike

Girth of each spike was measured from the mid portion of the spike and expressed in centimeters.

3.6.1.2.6 Length of rachis

Length of rachis of each spike was recorded in centimeters.

3.6.1.2.7 Number of florets

Total number of florets per spike was observed.

3.6.1.2.8 Size of florets

The length and breadth of each floret in a spike was recorded in centimeters.

3.6.1.2.9 Petiole length

Length from the base of the flower to the top of the petiole was measured and expressed in centimeters as petiole length.

3.6.1.2.10 Longevity of florets

Longevity of florets in the field was taken from the first floret opening to starting of wilting and expressed in days.

3.6.1.2.11 Longevity of spike in the field

Number of days taken for 50 per cent of the florets to wilt in each spike was noted.

3.6.1.2.12 Yield of spikes per hill

Yield of spikes per hill was noted and worked out as number of spikes/hill.

3.6.1.2.13 Vase life

Vase life of each spike in fresh water was noted and given as number of days.

3.7 Post harvest experiments

3.7.1 Bulb characters

3.7.1.2 Size of bulb or bulblets

Size of each bulb and bulblets in a hill was taken using a scale and recorded in centimeters.

3.7.1.3 Number of bulb or bulblets

Number of bulbs and bulblets from each hill was counted and recorded.

3.7.1.4 Weight of bulb or bulblets

Weight in grams of bulbs and bulblets in a hill was recorded.

3.7.2 Vase studies

The various pulsing treatments tried were as follows:

i) 8 HQS - 250 ppm, 500 ppm
ii) $AgNO_3$ - 50 ppm, 100 ppm
iii) Sucrose - 10 %, 15 %.

Vase studies were done with different holding solutions at different concentrations.

i) Sucrose - 2%, 4 %.

ii) 8 HQS - 200 ppm, 400 ppm

iii) $AgNO_3$ - 0.25 mM, 0.50 mM.

Spikes were harvested when the first pair of florets fully opened and were kept in pulsing solutions and there after in holding solutions. The following observations were taken.

3.7.2.1 Fresh weight of the spike

Fresh weight of the spike was noted and expressed in grams.

3.7.2.2 Days taken for opening of each floret

Number of days taken by each spike for opening of florets were taken and recorded.

3.7.2.3 Days to complete opening of florets

Number of days taken for all the florets to open was noted and recorded.

3.7.2.4 Number of florets opened at a time

Number of florets opened at a time in the vase was noted and recorded.

3.7.2.5 Total water uptake

The water uptake of each spike in the vase was observed and recorded in millilitre.

3.7.2.6 Vase life

Vase life of each spike was noted by collecting spikes and keeping in the desired solution at different concentration and counting the days taken for 50 per cent wilting of flowers.

3.7.2.8 Electrical conductivity (EC)

Electrical conductivity of the vase solution was measured and recorded. Electrical conductivity of the distilled water was also measured and the differences were recorded to get a relative measure of the electrolyte leached out from the spike and expressed in milli siemen per gram.

3.8 Analysis of data

The analysis of variance of the data was carried out using appropriate design as suggested by Panse and Sukhatme (1985). The m-STAT package available at the computer center of Department of Statistics was used for the study.

RESULTS

RESULTS

Studies were conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during the year 1998-2000 to find the effect of bio regulators on the vegetative and floral characters of tuberose, *Polianthes tuberosa* L. Studies were also conducted to standardize pulsing and holding solutions in tuberose. The results of the experiment are presented in this chapter.

4.1 Vegetative characters

Details on the growth parameters viz., Days to sprouting, percentage of sprouting, plant height, plant spread in the East–West and North–South directions, number of leaves, length of leaf, breadth of leaf, total leaf area and number of plants per hill at one month after planting to seven months after planting are given here under.

4.1.1 Days to sprouting

Data showing the number of days taken for sprouting of bulbs during the experiment are presented in Table 1. The control bulbs took only 15.83 days for sprouting, while the bulb dip treatments of paclobutrazol, CCC and BA took more time for sprouting. Among the three bio regulators, paclobutrazol was the earliest to sprout (13.33 and 12.00 days for 200 ppm) when applied 60 DAP.

4.1.2 Percentage of sprouting

All the treated plants and control showed cent per cent germination during the experiment (Table 1).

Table 1. Effect of bio regulators on sprouting

Treatments	Days to sprouting	Percentage of sprouting
Paclobutrazol 100 ppm Bulb dip	16.50	100
Paclobutrazol 200 ppm Bulb dip	16.33	100
Paclobutrazol 100 ppm 30 DAP	14.33	100
Paclobutrazol 200 ppm 30 DAP	15.33	100
Paclobutrazol 100 ppm 60 DAP	13.33	100
Paclobutrazol 200 ppm 60 DAP	12.00	100
CCC 500 ppm Bulb dip	17.67	100
CCC 1000 ppm Bulb dip	17.67	100
CCC 500 ppm 30 DAP	15.00	100
CCC 1000 ppm 30 DAP	15.17	100
CCC 500 ppm 60 DAP	14.84	100
CCC 1000 ppm 60 DAP	15.00	100
BA 50 ppm Bulb dip	20.50	100
BA 100 ppm Bulb dip	20.84	100
BA 50 ppm 30 DAP	21.50	100
BA 100 ppm 30 DAP	18.00	100
BA 50 ppm 60 DAP	17.50	100
BA 100 pm 60 DAP	18.83	100
Control	15.83	100
CD (0.05) SEm ±	1.70 0.39	NS

NS - Non significant

4.1.3 Plant height

The data on plant height as affected by various bio regulators are presented in Table 2.

Significant differences were noticed in the plant height as the observations were viewed. The data revealed that there was a progressive improvement in the height as time progresses. Among the treatments also significant differences could be observed. Minimum plant height was recorded with paclobutrzol 100 ppm bulb dip. During the first month a minimum plant height of 13.75 cm was noticed with paclobutrazol at its lower level which is statistically on par with paclobutrazol 200 ppm applied 60 DAP (13.98 cm), BA 50 ppm bulb dip (14.92 cm) and control (17.42 cm). The height increment 2 months after planting was highest for CCC 1000 ppm bulb dip (20.15 cm) and minimum increment was observed for paclobutrazol 100 ppm applied 30 DAP (2.42 cm), among the bulb dip and 30 DAP treatments. The height increment for paclobutrazol bulb dip varied greatly among the concentrations, where as the 30 DAP application did not register much difference among concentrations. In the case of CCC bulb dip 500 ppm registered less height increment than 1000 ppm. The BA bulb dip treatments did not show much variation among the concentrations in the first month of application, where as much difference was seen in the later months.

In the third month after planting, the height increment was lowest for CCC 500 ppm applied 30 DAP (0.66 cm) and paclobutrazol 100 ppm (0.93cm).

Table 2. Effect of bio regulators on plant height

Treatments	Plant height (cm)							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	13.75	31.00 (17.25)	32.75 (1.75)	36.17 (3.42)	37.25 (1.08)	41.14 (3.89)	47.35 (6.21)	33.60
Paclobutrazol 200 ppm Bulb dip	18.17	27.57 (9.40)	34.42 (6.85)	36.65 (2.23)	41.22 (4.59)	43.95 (2.73)	49.22 (5.27)	31.05
Paclobutrazol 100 ppm 30 DAP	27.33	31.06 (3.73)	35.09 (4.03)	35.75 (0.66)	44.56 (8.81)	49.48 (4.92)	50.04 (0.56)	22.71
Paclobutrazol 200 ppm 30 DAP	29.75	32.17 (2.42)	33.10 (0.93)	33.25 (0.15)	39.25 (6.00)	46.30 (7.05)	49.59 (3.29)	19.84
Paclobutrazol 100 ppm 60 DAP	18.67	28.67 (10.00)	30.17 (1.50)	33.88 (3.71)	39.25 (5.37)	45.99 (6.74)	49.57 (3.58)	30.90
Paclobutrazol 200 ppm 60 DAP	13.98	26.47 (12.49)	31.26 (4.79)	33.63 (2.37)	36.63 (3.00)	42.75 (6.12)	50.85 (8.10)	36.87
CCC 500 ppm Bulb dip	17.92	31.67 (13.75)	35.50 (3.83)	36.50 (1.00)	38.38 (1.88)	47.06 (8.68)	56.13 (9.07)	38.21
CCC 1000 ppm Bulb dip	17.91	38.06 (20.15)	42.50 (4.44)	44.25 (1.75)	49.78 (5.53)	51.57 (1.79)	61.15 (9.58)	43.24
CCC 500 ppm 30 DAP	28.25	34.17 (5.92)	34.83 (0.66)	36.88 (2.05)	43.94 (7.06)	45.17 (1.23)	54.97 (9.80)	26.72
CCC 1000 ppm 30 DAP	25.91	34.33 (8.42)	35.50 (1.17)	44.63 (9.13)	45.88 (1.25)	50.20 (4.23)	56.92 (6.72)	31.01
CCC 500 ppm 60 DAP	29.11	29.83 (0.72)	33.50 (3.67)	34.85 (1.35)	48.03 (13.18)	56.10 (8.07)	61.34 (5.24)	32.23
CCC 1000 ppm 60 DAP	27.92	30.34 (2.42)	36.50 (6.16)	38.13 (1.63)	50.42 (12.29)	59.21 (8.79)	63.23 (4.02)	35.31
BA 50 ppm Bulb dip	14.92	33.17 (18.25)	37.00 (3.83)	43.08 (6.08)	50.95 (7.87)	52.06 (1.11)	61.77 (9.71)	46.85
BA 100 ppm Bulb dip	16.12	34.41 (18.29)	38.50 (4.09)	58.00 (19.50)	59.80 (1.80)	62.91 (3.11)	65.05 (2.14)	48.93
BA 50 ppm 30 DAP	28.50	34.00 (5.50)	39.33 (5.30)	42.22 (2.89)	53.78 11.56)	54.97 (1.19)	61.02 (6.05)	29.44
BA 100 ppm 30 DAP	31.58	33.84 (2.26)	38.51 (4.67)	45.20 (6.69)	53.25 (8.05)	54.22 (0.97)	65.58 (11.36)	34.00
BA 50 ppm 60 DAP	24.17	35.50 (11.3)	39.88 (4.38)	43.17 (3.29)	51.38 (8.21)	52.19 (0.81)	66.16 (13.97)	41.99
BA 100 ppm 60 DAP	24.58	35.84 (11.26)	38.75 (2.91)	40.84 (2.09)	57.17 (16.33)	58.13 (0.96)	59.88 (1.75)	35.30
Control	17.42	28.43 (11.01)	33.84 (5.41)	36.38 (2.54)	41.06 (4.68)	43.27 (2.21)	45.00 (1.73)	27.52
CD (0.05)	1.86	5.06	2.63	9.98	3.20	2.42	10.00	
SEm ±	0.62	1.70	0.88	3.35	1.08	0.81	3.36	

NS – Non significant
Figures in parenthesis indicate the difference between monthly observations

All the treatments except paclobutrazol bulb dip had lower height increment than control.

In the fourth month after planting, paclobutrazol 30 DAP, CCC bulb dip and CCC 60 DAP registered lower height increment.

Five months after planting, bulb dip treatments eg., paclobutrazol 100 ppm, CCC 500 ppm and BA 100 ppm were found to show reduced height. Six months after planting, height reduction was maximum for CCC bulb dip and CCC 1000 ppm applied 30 DAP and BA bulb dip.

At flowering, the height reduction was maximum for paclobutrazol 100 and 200 ppm 30 DAP. The only other treatment which showed height reduction was CCC 1000 ppm bulb dip. The maximum height increment was observed for BA bulb dip treatments.

4.1.4 Plant Spread (E-W)

The results on the effects of bio regulators on plant spread (E-W) are presented in Table 3a.

The plant spread exhibited significant differences by the application of different bio regulators, concentration and time of application.

In the first month after planting, the paclobutrazol bulb dip treatments had the lowest plant spread (15.50 cm and 11.87 cm) which was on par with control, while the CCC bulb dip treatments had the highest plant spread (24.25 cm and 22.00 cm). But during the second month after planting, paclobutrazol bulb

Table. 3a. Effect of bio regulators on plant spread(E-W)

Treatments	Plant spread (E-W) cm							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	15.50	35.75 (20.25)	36.95 (1.20)	41.90 (4.95)	42.30 (0.40)	42.50 (0.20)	45.90 (3.40)	30.40
Paclobutrazol 200 ppm Bulb dip	11.875	26.00 (14.13)	34.00 (8.00)	37.55 (3.55)	42.50 (4.95)	44.35 (1.85)	45.50 (1.15)	33.63
Paclobutrazol 100 ppm 30 DAP	26.00	29.80 (3.80)	35.10 (5.30)	35.75 (0.65)	40.85 (5.10)	44.30 (3.45)	45.10 (0.80)	19.10
Paclobutrazol 200 ppm 30 DAP	31.75	33.30 (1.55)	35.35 (2.05)	38.00 (2.65)	38.35 (0.35)	40.00 (1.65)	41.85 (1.85)	10.10
Paclobutrazol 100 ppm 60 DAP	15.25	32.75 (1.75)	37.30 (4.55)	43.50 (6.20)	45.75 (2.25)	47.00 (1.25)	47.45 (0.45)	32.20
Paclobutrazol 200 ppm 60 DAP	14.75	34.45 (19.65)	36.00 (1.55)	37.95 (1.95)	38.85 (0.90)	40.00 (1.05)	40.50 (0.50)	25.75
CCC 500 ppm Bulb dip	24.25	36.95 (12.70)	40.50 (3.55)	40.70 (0.20)	40.80 (0.10)	41.20 (1.40)	44.25 (2.05)	20.00
CCC 1000 ppm Bulb dip	22.00	33.45 (12.45)	35.90 (2.45)	39.35 (3.45)	39.80 (0.45)	41.50 (1.70)	51.20 (9.70)	29.20
CCC 500 ppm 30 DAP	31.50	38.50 (7.00)	39.35 (0.85)	45.65 (6.03)	45.85 (0.20)	46.80 (0.95)	49.10 (2.30)	17.60
CCC 1000 ppm 30 DAP	29.25	35.25 (6.00)	46.60 (11.35)	49.40 (2.80)	51.80 (2.40)	51.90 (0.10)	52.10 (0.20	22.85
CCC 500 ppm 60 DAP	31.25	38.10 (6.85)	39.10 (1.00)	40.80 (1.70)	41.90 (1.10)	45.60 (3.70)	46.90 (1.30)	15.65
CCC 1000 ppm 60 DAP	26.75	39.80 (13.50)	40.00 (0.20)	41.40 (1.40)	45.00 (3.60)	47.90 (2.90)	48.15 (0.25)	21.40
BA 50 ppm Bulb dip	16.50	39.00 (22.50)	39.05 (0.50)	39.70 (0.65)	40.25 (6.55)	48.35 (8.10)	50.00 (1.65)	23.50
BA 100 ppm Bulb dip	17.00	31.35 (14.35)	40.50 (9.15)	43.00 (2.50)	46.25 (3.25)	49.00 (2.75)	49.10 (0.10)	18.60
BA 50 ppm 30 DAP	30.50	33.45 (2.95)	38.75 (5.30)	39.50 (0.75)	43.20 (3.70)	44.50 (1.30)	49.05 (4.55)	15.05
BA 100 ppm 30 DAP	34.00	38.00 (4.00)	41.10 (3.10)	41.20 (0.100	43.50 (2.30)	46.50 (3.00)	46.50 (0.00)	12.50
BA 50 ppm 60 DAP	28.50	38.75 (10.25)	48.70 (9.95)	45.20 (3.50)	48.10 (2.90)	51.10 (3.00)	51.00 (0.10)	22.50
BA 100 ppm 60 DAP	28.225	34.25 (6.03)	39.81 (5.56)	42.55 (2.74)	43.75 (1.20)	48.80 (5.05)	54.00 (5.20)	25.78
Control	15.50	37.25 (21.75)	44.50 (7.25)	46.55 (2.05)	50.15 (3.60)	51.55 (1.40)	54.15 (2.60)	38.65
CD (0.05)	9.44	9.16	9.12	9.54	15.02	7.64	6.45	
SEm ±	3.17	3.08	3.07	3.21	5.05	2.57	2.17	

NS – Non significant
Figures in parenthesis indicate the difference between monthly observations

dip treatments recorded maximum increase in plant spread. During the third month, paclobutrazol bulb dip at 200 ppm, paclobutrazol 100 ppm 30 DAP, CCC 1000 ppm applied 30 DAP and BA 100 ppm bulb dip and BA 50 ppm applied 60 DAP had the maximum increase in plant spread. Paclobutrazol applied 30 DAP resulted in lowest increase in plant spread (19.1 cm and 10.1 cm).

4.1.5 Plant spread (N-S)

The results on the plant spread as affected by bio regulators are presented in Table 3b.

Paclobutrazol bulb dip treatments recorded highest increase in plant spread (N-S). The other bulb dip treatments viz., CCC 1000 ppm and BA 50 ppm and 100 ppm also showed good plant spread. Lowest increase in plant spread was observed for paclobutrazol 100 ppm applied 30 DAP.

4.1.6 Number of leaves

The results on the effect of plant bio regulators on number of leaves are presented in Table 4.

Application of all bio regulators increased the leaf number as compared to control. Among the treatments paclobutrazol and BA bulb dip were the best. Paclobutrazol registered an increase of 55.86 and 50.01 from the initial number for 100 ppm and 200 ppm respectively, whereas paclobutrazol applied 30 DAP had the lowest number of leaves.

Table 3b. Effect of bio regulators on plant spread (N-S)

Treatments	Plant Spread (N-S) (cm)							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	13.50	30.00 (16.50)	31.00 (1.00)	35.00 (4.00)	36.60 (1.60)	44.00 (7.40)	50.20 (6.20)	36.70
Paclobutrazol 200 ppm Bulb dip	10.00	30.25 (20.25)	30.40 (0.15)	31.45 (1.05)	31.60 (0.15)	31.75 (0.15)	32.15 (0.40)	22.15
Paclobutrazol 100 ppm 30 DAP	33.50	37.50 (4.00)	37.90 (0.20)	40.20 (2.30)	41.30 (1.10)	41.80 (0.90)	41.90 (0.10)	8.40
Paclobutrazol 200 ppm 30 DAP	15.75	29.50 (13.75)	29.95 (0.45)	33.15 (3.20)	35.05 (1.90)	36.80 (1.75)	37.50 (0.70)	21.75
Paclobutrazol 100 ppm 60 DAP	17.25	37.50 (20.25)	46.10 (8.60)	47.90 (1.80)	48.00 (0.10)	48.50 (0.50)	49.10 (0.60)	31.85
Paclobutrazol 200 ppm 60 DAP	13.50	29.00 (15.50)	30.10 (1.10)	31.50 (1.40)	33.30 (1.80)	33.40 (0.10)	34.00 (0.60)	20.50
CCC 500 ppm Bulb dip	24.50	32.50 (8.00)	41.55 (9.05)	45.80 (4.25)	48.00 (2.20)	44.55 (3.45)	42.40 (2.15)	17.90
CCC 1000 ppm Bulb dip	21.50	40.50 (19.00)	40.70 (0.20)	51.05 (10.35)	51.09 (0.04)	53.55 (2.46)	54.00 (0.45)	32.50
CCC 500 ppm 30 DAP	28.00	34.25 (6.25)	38.35 (4.10)	43.90 (5.55)	51.70 (7.80)	52.10 (0.40)	52.80 (0.70)	24.80
CCC 1000 ppm 30 DAP	30.25	30.25 (0.00)	32.35 (2.10)	33.20 (0.85)	34.00 (0.80)	51.50 (17.50)	51.50 (0.00)	21.25
CCC 500 ppm 60 DAP	31.75	30.30 (1.45)	30.45 (0.15)	37.05 (6.60)	45.10 (8.05)	45.50 (0.40)	46.25 (0.75)	14.50
CCC 1000 ppm 60 DAP	22.00	30.15 (8.15)	33.95 (3.80)	36.00 (2.05)	38.15 (2.15)	41.25 (3.10)	50.60 (9.35)	28.60
BA 50 ppm Bulb dip	17.00	39.50 (22.50)	39.88 (0.38)	48.10 (8.22)	51.20 (3.10)	51.50 (0.30)	51.50 (0.00)	34.50
BA 100 ppm Bulb dip	18.50	37.00 (18.50)	37.90 (0.90)	45.40 (7.50)	47.25 (1.85)	52.60 (5.35)	53.55 (0.95)	35.05
BA 50 ppm 30 DAP	29.25	30.70 (1.45)	33.00 (2.30)	35.00 (2.00)	39.65 (4.65)	48.00 (8.35)	48.30 (0.30)	19.05
BA 100 ppm 30 DAP	34.00	43.35 (9.35)	48.50 (5.15)	52.75 (4.25)	58.45 (5.70)	58.50 (0.05)	59.35 (4.45)	25.35
BA 50 ppm 60 DAP	31.50	41.25 (9.75)	42.45 (1.20)	42.50 (0.05)	43.10 (0.60)	49.90 (6.80)	54.35 (0.86)	22.85
BA 100 ppm 60 DAP	26.25	32.20 (5.95)	34.70 (2.50)	36.75 (2.05)	39.80 (3.05)	40.25 (0.45)	48.85 (8.60)	22.60
Control	17.00	29.00 (12.00)	33.00 (4.00)	35.25 (2.25)	39.90 (4.65)	40.95 (1.05)	42.50 (1.55)	25.50
CD (0.05)	10.60	9.71	NS	11.14	NS	11.49	5.39	
SEm ±	3.56	3.27		3.75		3.86	1.81	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

Table 4. Effect of bio regulators on number of leaves

Treatments	Number of leaves							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	10.83	19.03 (8.20)	28.12 (9.09)	41.23 (13.11)	60.30 (19.12)	62.22 (1.87)	66.69 (4.47)	55.86
Paclobutrazol 200 ppm Bulb dip	14.83	20.58 (5.75)	24.08 (3.50)	38.75 (14.67)	44.91 (6.16)	49.12 (4.21)	54.84 (5.72)	50.01
Paclobutrazol 100 ppm 30 DAP	10.88	17.59 (6.71)	25.08 (7.49)	26.50 (1.42)	36.94 (10.44)	43.89 (6.95)	47.55 (3.66)	36.67
Paclobutrazol 200 ppm 30 DAP	12.92	13.18 (0.26)	20.92 (7.74)	24.32 (3.40)	32.59 (8.27)	39.10 (6.51)	51.94 (12.84)	39.02
Paclobutrazol 100 ppm 60 DAP	9.00	10.51 (1.51)	18.48 (7.97)	30.65 (12.17)	39.17 (8.52)	43.12 (3.95)	45.7 (2.58)	36.70
Paclobutrazol 200 ppm 60 DAP	11.50	19.09 (7.59)	23.17 (4.08)	39.44 (16.27)	46.95 (7.51)	51.75 (4.80)	53.27 (1.52)	41.77
CCC 500 ppm Bulb dip	12.59	20.33 (7.74)	31.28 (10.95)	50.83 (19.55)	51.77 (0.94)	58.80 (7.03)	60.35 (1.55)	47.76
CCC 1000 ppm Bulb dip	9.92	18.05 (8.13)	34.63 (16.58)	48.88 (14.25)	52.50 (3.32)	56.01 (3.81)	58.69 (2.68)	48.77
CCC 500 ppm 30 DAP	12.75	28.42 (15.67)	33.67 (0.25)	39.57 (5.90)	45.57 (6.00)	50.95 (5.38)	55.70 (4.75)	42.95
CCC 1000 ppm 30 DAP	13.00	24.92 (11.92)	25.17 (3.50)	34.91 (9.74)	42.27 (7.36)	51.95 (9.68)	55.99 (4.04)	42.99
CCC 500 ppm 60 DAP	13.09	29.84 (16.75)	33.34 (15.30)	43.82 (10.48)	49.13 (5.31)	56.19 (7.06)	60.75 (4.56)	47.66
CCC 1000 ppm 60 DAP	9.67	12.95 (3.28)	28.25 (14.76)	38.54 (10.29)	51.32 (12.78)	56.11 (4.79)	59.77 (3.66)	50.10
BA 50 ppm Bulb dip	9.67	13.45 (3.78)	27.01 (8.21)	36.09 (9.08)	46.66 (10.57)	55.99 (9.33)	61.25 (5.26)	51.58
BA 100 ppm Bulb dip	8.67	17.62 (8.95)	25.83 (4.17)	45.14 (14.49)	52.75 (7.61)	61.25 (8.50)	63.51 (2.26)	54.84
BA 50 ppm 30 DAP	11.76	22.58 (10.82)	26.75 (10.58)	32.00 (5.25)	41.77 (9.77)	50.87 (9.10)	51.85 (0.98)	50.09
BA 100 ppm 30 DAP	14.50	25.42 (10.92)	36.00 (15.50)	45.00 (9.00)	48.50 (3.50)	60.25 (11.75)	60.95 (0.70)	46.45
BA 50 ppm 60 DAP	12.09	23.50 (11.41)	39.00 (13.91)	42.10 (3.10)	49.69 (7.51)	56.16 (6.47)	59.66 (3.50)	47.57
BA 100 ppm 60 DAP	17.25	28.09 (10.84)	42.00 (14.83)	44.03 (2.03)	55.75 (11.72)	56.88 (1.13)	58.53 (1.65)	41.28
Control	8.25	12.59 (4.34)	19.08 (6.50)	21.66 (2.58)	24.35 (2.69)	26.03 (1.68)	35.67 (9.64)	27.42
CD (0.05)	1.62	2.13	2.69	2.12	2.66	0.90	3.85	
SEm ±	0.54	0.71	0.90	0.71	0.89	0.63	1.29	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

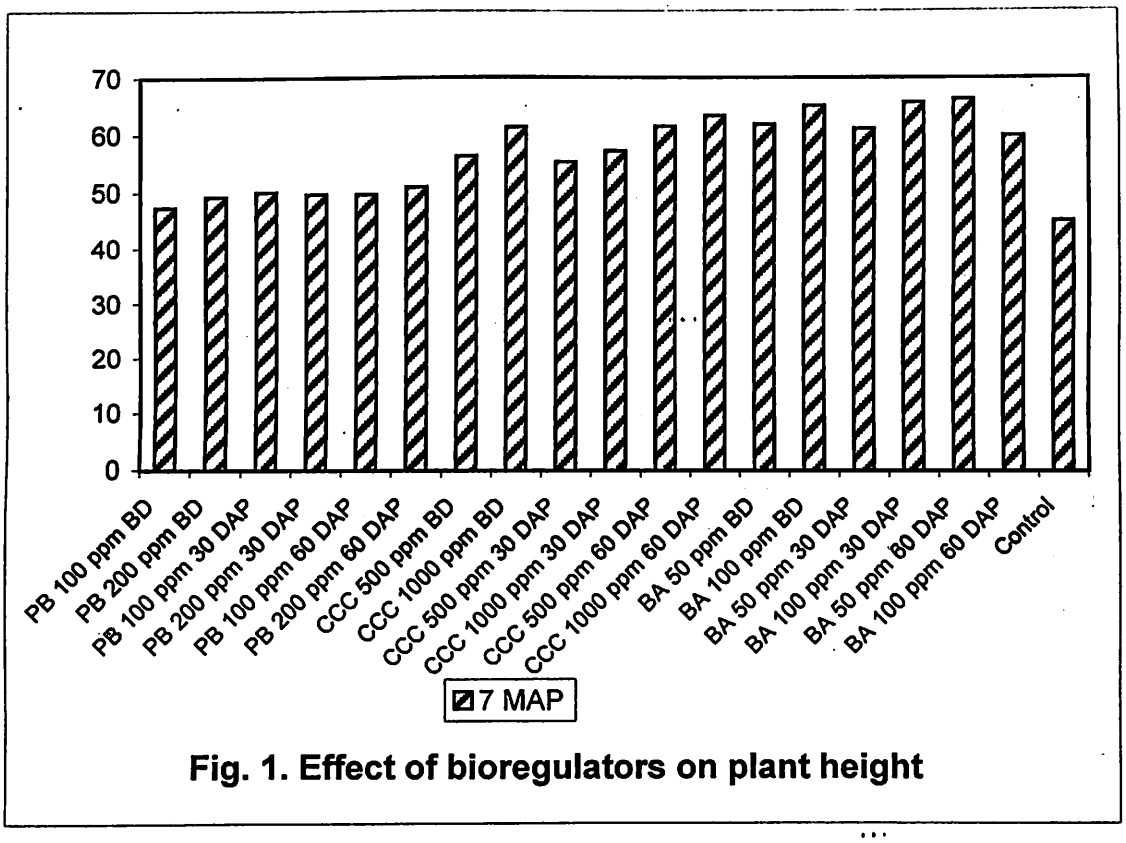


Fig. 1. Effect of bioregulators on plant height

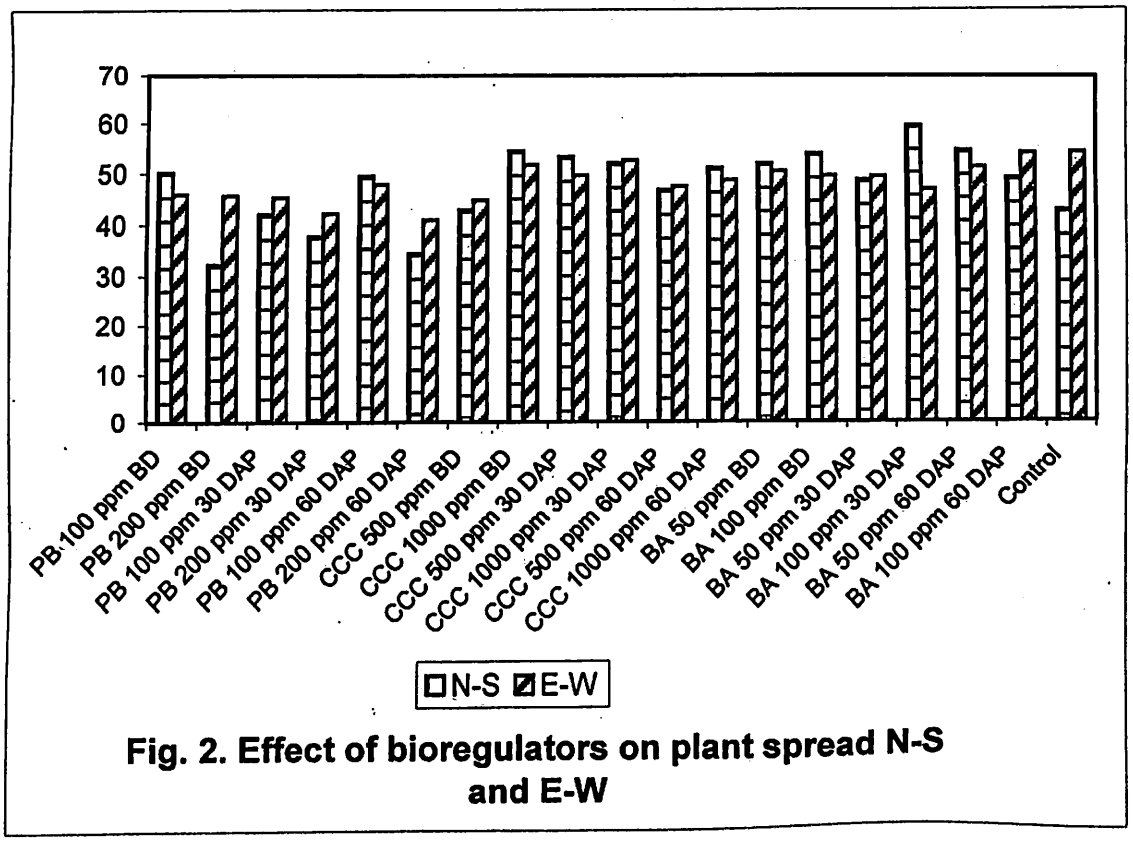


Fig. 2. Effect of bioregulators on plant spread N-S and E-W

Paclobutrazol - PB
Bulb dip - BD

4.1.7 Length of leaf

The data on the length of leaf as affected by bio regulators are presented in Table 5.

The length of leaf was found to be highly influenced by application of bio regulators. In general, the bulb dip treatments had longer leaves, with CCC 1000 ppm (49.68 cm) and BA 50 (43.67cm) and 100 ppm (40.65cm). Bio regulators applied 30 DAP produced shorter leaves, shortest being produced by paclobutrazol 200 ppm (19.54 cm length increase) and CCC 500 ppm (19.54 cm length increase).

4.1.8 Breadth of leaf

The influence of bio regulators on leaf breadth are presented in Table 6.

During the first month of planting, there was no difference among the treatments. But 7 MAP, all the treatments produced significantly broader leaves as compared to control. Paclobutrazol 200 ppm 60 DAP had the broadest leaves (1.93 cm) followed by BA 50 (1.75 cm) and 100 ppm 60 DAP (1.76 cm). The treatments paclobutrazol 200 ppm applied (1.44 cm) 30 DAP and CCC 500 ppm applied 60 DAP (1.37 cm) were found to be insignificant when compared to control (1.45 cm).

4.1.8 Total leaf area

The results of the total leaf area as influenced by bio regulators are presented in Table 7.

Table 5. Effect of bio regulators on length of leaves

Treatments	Length of leaf (cm)							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	13.50	26.11 (12.61)	30.00 (3.89)	31.50 (1.50)	33.38 (1.88)	39.74 (6.36)	45.03 (5.29)	31.53
Paclobutrazol 200 ppm Bulb dip	16.55	26.50 (9.45)	30.35 (3.85)	33.19 (2.84)	38.55 (5.36)	41.70 (3.15)	46.98 (5.28)	30.43
Paclobutrazol 100 ppm 30 DAP	26.00	28.33 (2.33)	32.92 (4.59)	34.50 (1.58)	38.35 (3.85)	44.04 (5.69)	47.645 (3.60)	21.64
Paclobutrazol 200 ppm 30 DAP	25.59	30.23 (4.64)	30.42 (0.19)	31.88 (1.46)	36.15 (4.27)	43.72 (7.57)	45.13 (1.41)	19.54
Paclobutrazol 100 ppm 60 DAP	14.00	27.51 (13.51)	29.09 (1.58)	32.88 (3.79)	36.63 (3.75)	40.33 (3.70)	45.27 (4.94)	31.27
Paclobutrazol 200 ppm 60 DAP	13.34	23.02 (9.68)	27.76 (4.74)	30.94 (3.18)	34.76 (3.82)	38.34 (3.58)	41.73 (3.39)	28.39
CCC 500 ppm Bulb dip	16.04	29.06 (13.02)	32.42 (3.36)	35.13 (2.71)	38.63 (3.50)	45.58 (6.95)	51.07 (5.49)	35.03
CCC 1000 ppm Bulb dip	13.74	34.09 (20.35)	39.34 (5.25)	42.94 (3.60)	46.39 (3.45)	54.45 (8.06)	63.42 (8.97)	49.68
CCC 500 ppm 30 DAP	27.58	32.34 (4.76)	34.00 (1.66)	35.75 (1.75)	39.13 (3.38)	41.78 (2.65)	47.22 (5.44)	19.64
CCC 1000 ppm 30 DAP	23.50	32.50 (9.00)	35.17 (2.67)	39.38 (4.21)	43.25 (3.87)	45.62 (2.37)	51.14 (5.52)	27.64
CCC 500 ppm 60 DAP	26.42	28.17 (1.75)	32.67 (4.50)	33.50 (0.83)	38.63 (5.13)	47.42 (8.79)	56.37 (8.95)	29.95
CCC 1000 ppm 60 DAP	25.13	27.42 (2.29)	34.84 (7.42)	35.32 (0.48)	43.25 (7.93)	51.54 (8.29)	60.14 (8.60)	35.01
BA 50 ppm Bulb dip	13.54	30.09 (16.55)	33.17 (3.08)	35.88 (2.71)	37.32 (1.44)	50.44 (13.12)	57.21 (6.77)	43.67
BA 100 ppm Bulb dip	15.00	32.67 (17.67)	33.17 (0.50)	37.50 (4.33)	39.90 (2.40)	47.54 (7.64)	55.65 (8.11)	40.65
BA 50 ppm 30 DAP	27.25	32.16 (4.91)	34.34 (2.18)	38.63 (4.29)	43.38 (4.75)	50.78 (7.40)	52.92 (2.14)	25.67
BA 100 ppm 30 DAP	29.42	32.67 (3.25)	34.34 (1.67)	39.25 (4.91)	41.31 (1.18)	51.93 (10.62)	58.79 (6.86)	29.37
BA 50 ppm 60 DAP	22.08	29.09 (7.01)	37.17 (8.08)	38.79 (1.62)	43.99 (5.20)	48.93 (4.94)	58.04 (9.11)	35.96
BA 100 ppm 60 DAP	24.08	29.67 (5.59)	32.25 (2.58)	35.07 (2.87)	43.38 (8.31)	50.52 (7.14)	60.64 (10.12)	36.56
Control	14.26	28.00 (13.74)	31.76 (3.76)	35.69 (3.93)	38.48 (2.79)	41.12 (2.64)	43.39 (2.27)	29.13
CD (0.05)	1.77	2.15	3.70	1.85	2.10	1.54	1.60	
SEm ±	0.59	0.72	1.24	0.62	0.70	0.59	0.54	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

Table 6. Effect of bio regulators on breadth of leaves

Treatments	Breadth of leaf (cm)							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	1	1.07 (0.07)	1.380 (0.31)	1.42 (0.04)	1.47 (0.05)	1.51 (0.04)	1.68 (0.17)	0.68
Paclobutrazol 200 ppm Bulb dip	1	1.32 (0.32)	1.31 (0.01)	1.34 (0.03)	1.39 (0.05)	1.58 (0.19)	1.59 (0.01)	0.59
Paclobutrazol 100 ppm 30 DAP	1	1.27 (0.27)	1.53 (0.26)	1.66 (0.13)	1.70 (0.04)	1.72 (0.02)	1.73 (0.01)	0.73
Paclobutrazol 200 ppm 30 DAP	1	1.02 (0.02)	1.26 (0.24)	1.26 (0.00)	1.27 (0.01)	1.41 (0.14)	1.44 (0.03)	0.44
Paclobutrazol 100 ppm 60 DAP	1	1.15 (0.15)	1.15 (0.00)	1.24 (0.09)	1.34 (0.10)	1.41 (0.07)	1.50 (0.09)	0.50
Paclobutrazol 200 ppm 60 DAP	1	1.05 (0.05)	1.38 (0.33)	1.53 (0.15)	1.6 (0.07)	1.8 (0.20)	1.93 (0.13)	0.93
CCC 500 ppm Bulb dip	1	1.21 (0.21)	1.37 (0.16)	1.38 (0.01)	1.48 (0.10)	1.58 (0.10)	1.64 (0.06)	0.64
CCC 1000 ppm Bulb dip	1	1.15 (0.15)	1.43 (0.08)	1.44 (0.01)	1.46 (0.02)	1.48 (0.02)	1.50 (0.02)	0.50
CCC 500 ppm 30 DAP	1	1.09 (0.09)	1.25 (0.16)	1.37 (0.12)	1.42 (0.05)	1.45 (0.03)	1.48 (0.03)	0.48
CCC 1000 ppm 30 DAP	1	1.24 (0.24)	1.35 (0.11)	1.37 (0.02)	1.38 (0.01)	1.52 (0.14)	1.65 (0.13)	0.65
CCC 500 ppm 60 DAP	1	1.13 (0.13)	1.23 (0.10)	1.25 (0.02)	1.26 (0.01)	1.35 (0.09)	1.37 (0.02)	0.37
CCC 1000 ppm 60 DAP	1	1.10 (0.10)	1.38 (0.28)	1.49 (0.11)	1.49 (0.00)	1.50 (0.01)	1.51 (0.01)	0.51
BA 50 ppm Bulb dip	1	1.05 (0.05)	1.28 (0.23)	1.32 (0.04)	1.39 (0.07)	1.42 (0.03)	1.45 (0.03)	0.45
BA 100 ppm Bulb dip	1	1.08 (0.08)	1.38 (0.30)	1.41 (0.03)	1.45 (0.04)	1.45 (0.00)	1.48 (0.03)	0.48
BA 50 ppm 30 DAP	1	1.03 (0.03)	1.28 (0.25)	1.47 (0.19)	1.48 (0.01)	1.50 (0.02)	1.58 (0.08)	0.58
BA 100 ppm 30 DAP	1	1.09 (0.09)	1.29 (0.20)	1.33 (0.04)	1.38 (0.05)	1.42 (0.04)	1.45 (0.03)	0.45
BA 50 ppm 60 DAP	1	1.14 (0.14)	1.25 (0.11)	1.29 (0.04)	1.31 (0.02)	1.38 (0.07)	1.75 (0.37)	0.49
BA 100 ppm 60 DAP	1	1.10 (0.10)	1.31 (0.21)	1.38 (0.07)	1.60 (0.22)	1.69 (0.09)	1.76 (0.07)	0.74
Control	1	1.05 (0.05)	1.32 (0.27)	1.42 (0.10)	1.44 (0.02)	1.45 (0.01)	1.45 (0.00)	0.45
CD (0.05)	NS	0.20	0.06	0.12	0.30	0.10	0.07	
SEm ±		0.07	0.02	0.04	0.10	0.03	0.02	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

Table 7. Effect of bio regulators on total leaf area

Treatments	Total leaf area (cm^2)							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	103.02	341.86 (238.84)	722.86 (381.00)	1126.80 (403.94)	1846.80 (720.00)	2116.70 (269.90)	3231.80 (1794.00)	3128.78
Paclobutrazol 200 ppm Bulb dip	154.39	458.61 (304.22)	685.09 (226.48)	1123.85 (438.76)	1688.95 (565.10)	1705.05 (16.10)	2457.45 (752.40)	2303.06
Paclobutrazol 100 ppm 30 DAP	184.03	337.37 (153.34)	838.02 (500.65)	1042.85 (204.83)	1722.52 (679.67)	1498.50 (224.02)	2484.80 (986.30)	2300.77
Paclobutrazol 200 ppm 30 DAP	215.18	259.77 (44.52)	572.37 (312.60)	772.27 (199.90)	1933.36 (1161.09)	1540.50 (392.86)	1593.70 (53.20)	1378.52
Paclobutrazol 100 ppm 60 DAP	87.83	211.73 (123.90)	482.19 (270.46)	697.09 (214.90)	933.55 (236.46)	1323.90 (390.35)	1909.55 (585.65)	1821.72
Paclobutrazol 200 ppm 60 DAP	108.29	301.94 (193.65)	697.85 (395.91)	1444.15 (746.30)	1484.32 (40.17)	1743.05 (258.73)	2089.55 (346.50)	1981.26
CCC 500 ppm Bulb dip	132.02	454.77 (322.75)	870.36 (415.59)	1576.45 (706.09)	2039.11 (1574.06)	2280.35 (241.24)	3091.85 (814.50)	2959.83
CCC 1000 ppm Bulb dip	96.00	446.67 (350.67)	1251.45 (804.78)	1732.35 (480.09)	1910.74 (178.39)	2495.40 (584.66)	3006.00 (510.60)	2910.00
CCC 500 ppm 30 DAP	227.71	633.78 (406.07)	897.71 (263.93)	1275.25 (377.54)	1722.40 (447.15)	1700.25 (22.15)	2402.65 (702.40)	2174.94
CCC 1000 ppm 30 DAP	200.37	678.57 (478.20)	676.32 (2.25)	1291.20 (614.88)	1868.61 (577.41)	1913.25 (44.64)	2418.60 (505.35)	2218.23
CCC 500 ppm 60 DAP	223.91	657.35 (433.44)	919.40 (262.05)	1100.35 (180.95)	1188.67 (88.32)	2228.85 (1040.18)	2793.35 (564.50)	2569.44
CCC 1000 ppm 60 DAP	155.98	250.96 (94.98)	920.86 (669.90)	1261.40 (340.54)	1633.59 (372.19)	2222.90 (589.39)	3365.70 (1142.80)	3210.62
BA 50 ppm Bulb dip	90.23	270.13 (179.90)	871.75 (601.62)	1180.20 (308.45)	1900.59 (720.39)	2483.35 (582.76)	3037.40 (584.05)	2947.17
BA 100 ppm Bulb dip	89.88	403.41 (313.53)	873.19 (469.78)	1521.8 (648.61)	1872.08 (350.78)	2403.25 (531.17)	3178.60 (775.35)	3088.72
BA 50 ppm 30 DAP	207.55	447.20 (239.65)	738.99 (291.79)	1123.05 (384.06)	1664.55 (541.50)	2086.20 (421.65)	2892.85 (806.65)	2685.30
BA 100 ppm 30 DAP	274.74	669.67 (394.93)	1672.48 (1002.81)	1984.81 (312.33)	2295.68 (310.89)	2783.35 (487.67)	3954.20 (1170.90)	3679.80
BA 50 ppm 60 DAP	176.37	446.52 (270.15)	1593.85 (1147.33)	1698.25 (104.40)	2195.58 (494.33)	2481.35 (285.77)	3053.30 (571.95)	2876.93
BA 100 ppm 60 DAP	272.21	585.68 (313.47)	1118.05 (532.37)	1198.45 (80.40)	2283.99 (1085.54)	2654.75 (370.76)	4010.40 (1351.25)	3738.19
Control	82.05	238.48 (156.43)	502.82 (264.34)	707.12 (204.32)	894.75 (187.63)	937.22 (87.47)	1325.45 (388.23)	1243.40
CD (0.05)	20.71	61.38	81.95	275.53	159.02	126.60	195.44	
SEm ±	6.97	20.66	27.58	92.74	53.52	42.61	65.78	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

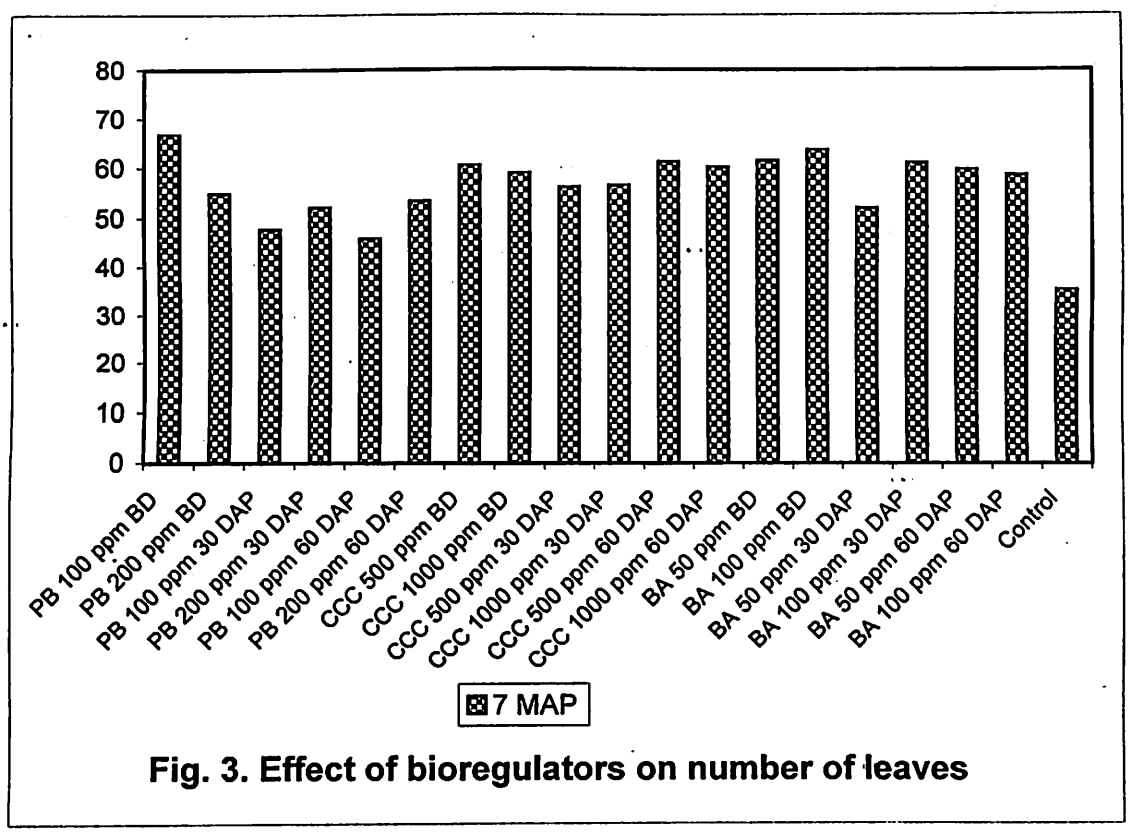


Fig. 3. Effect of bioregulators on number of leaves

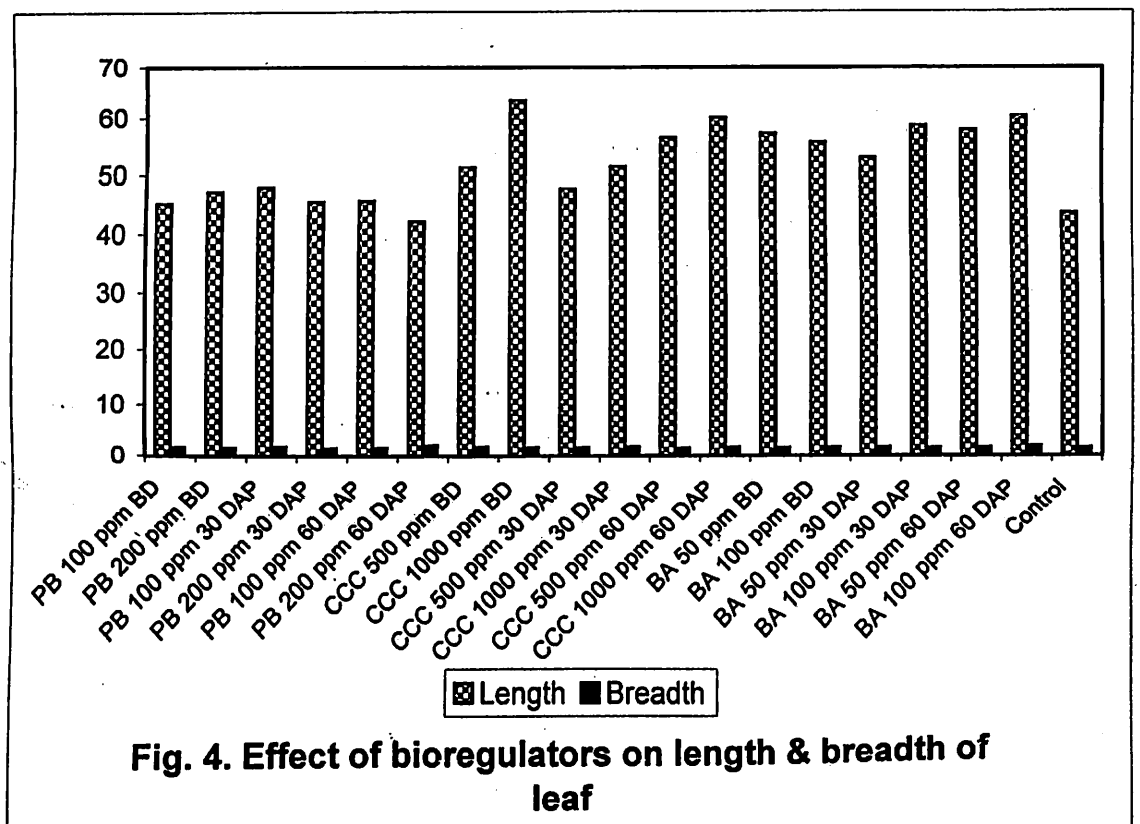


Fig. 4. Effect of bioregulators on length & breadth of leaf

Paclobutrazol - PB
Bulb dip - BD

In the first month after planting, total leaf area was highest for BA 100 ppm applied 30 DAP (274.74 cm^2) followed by BA 100 ppm applied at 60 DAP (272.21 cm^2). Among the paclobutrazol treatments 100 ppm and 200 ppm applied 30 DAP had the maximum leaf area. Among the CCC treatments CCC 500 ppm applied 30 DAP (227.71 cm^2) and 60 DAP were the best (223.91 cm^2).

By the second month, the increase in total leaf area over the first month was highest for CCC 1000 ppm applied 30 DAP followed by CCC 500 ppm applied 60 DAP. Almost all the treatments exhibited improvement in total leaf area than that of control.

The control plants recorded the minimum leaf area (1325.45 cm^2), which was significantly lower than all treatments. The total leaf area was the highest for BA 100 ppm 60 DAP (4010.40 cm^2), closely followed by BA 100 ppm 30 DAP (3954.20 cm^2).

Paclobutrazol 100 ppm bulb dip recorded maximum increase in leaf area than the initial month (3128.78 cm^2), which was much higher.

4.1.9 Number of tillers per hill

Tiller production started from third month onwards in control and treatments. Significant difference was observed in number of tillers in third, fourth, fifth, sixth and seventh months. In the 3rd, 4th and 5th months, maximum tillers were produced by plants receiving CCC 1000 ppm bulb dip (4.13, 4.38, 4.5). But later in the 6th and 7th months, tiller production became more in the plants treated with BA 50 ppm applied at 60 DAP (7.74, 8.88), which is on par with BA 50 ppm

Table. 8. Effect of bio regulators on number of plants per hill

Treatments	Number of plants / hill							Total increment
	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	
Paclobutrazol 100 ppm Bulb dip	-	-	3.83 (3.83)	4.50 (0.67)	4.62 (0.12)	4.62 (0.00)	4.75 (0.13)	0.92
Paclobutrazol 200 ppm Bulb dip	-	-	2.09 (2.09)	2.38 (0.29)	2.38 (0.00)	2.92 (0.54)	4.13 (1.21)	2.04
Paclobutrazol 100 ppm 30 DAP	-	-	1.59 (1.59)	1.65 (0.06)	1.75 (0.10)	2.00 (0.25)	4.13 (2.13)	2.54
Paclobutrazol 200 ppm 30 DAP	-	-	1.75 (1.75)	1.82 (0.07)	2.00 (0.18)	2.00 (0.00)	2.25 (0.25)	0.50
Paclobutrazol 100 ppm 60 DAP	-	-	3.50 (3.50)	3.67 (0.17)	4.00 (0.33)	4.75 (0.75)	5.00 (0.25)	1.50
Paclobutrazol 200 ppm 60 DAP	-	-	1.33 (1.33)	2.38 (1.05)	2.38 (0.00)	2.88 (0.50)	4.50 (1.62)	3.17
CCC 500 ppm Bulb dip	-	-	3.38 (3.38)	4.34 (0.96)	4.63 (0.29)	4.75 (0.12)	6.50 (1.75)	3.12
CCC 1000 ppm Bulb dip	-	-	4.13 (4.13)	4.38 (0.25)	4.50 (0.12)	4.75 (0.25)	4.80 (0.05)	0.67
CCC 500 ppm 30 DAP	-	-	1.67 (1.67)	2.00 (0.33)	2.63 (0.63)	2.75 (0.12)	4.63 (1.88)	2.96
CCC 1000 ppm 30 DAP	-	-	2.17 (2.17)	2.00 (0.17)	2.75 (0.75)	3.63 (0.88)	4.00 (0.37)	1.83
CCC 500 ppm 60 DAP	-	-	1.75 (1.75)	1.88 (0.13)	2.00 (0.12)	3.38 (1.38)	3.90 (0.52)	2.15
CCC 1000 ppm 60 DAP	-	-	1.85 (1.85)	2.00 (0.15)	2.50 (0.50)	5.63 (3.13)	6.38 (0.75)	4.53
BA 50 ppm Bulb dip	-	-	2.83 (2.83)	3.60 (0.77)	4.05 (0.45)	4.55 (0.50)	6.13 (1.58)	3.30
BA 100 ppm Bulb dip	-	-	2.67 (2.67)	3.50 (0.83)	4.00 (0.50)	4.25 (0.25)	4.25 (0.00)	1.58
BA 50 ppm 30 DAP	-	-	2.33 (2.33)	2.38 (0.05)	2.38 (0.00)	3.88 (0.50)	5.63 (1.75)	4.30
BA 100 ppm 30 DAP	-	-	3.00 (3.00)	3.13 (0.13)	3.75 (0.62)	4.00 (0.25)	4.50 (0.05)	1.50
BA 50 ppm 60 DAP	-	-	2.17 (2.17)	2.88 (0.71)	3.88 (1.00)	7.74 (3.86)	8.88 (1.14)	6.71
BA 100 ppm 60 DAP	-	-	2.67 (2.67)	2.75 (0.08)	3.50 (0.75)	6.13 (2.63)	8.25 (2.12)	5.58
Control	-	-	3.50 (3.50)	3.55 (0.05)	4.25 (0.70	5.63 (1.38)	5.50 (0.13)	2.00
CD (0.05)	NS	NS	1.07	0.88	0.81	0.38	1.00	
SEm ±			0.38	0.29	0.27	0.46	0.33	

NS - Non significant
Figures in parenthesis indicate the difference between monthly observations

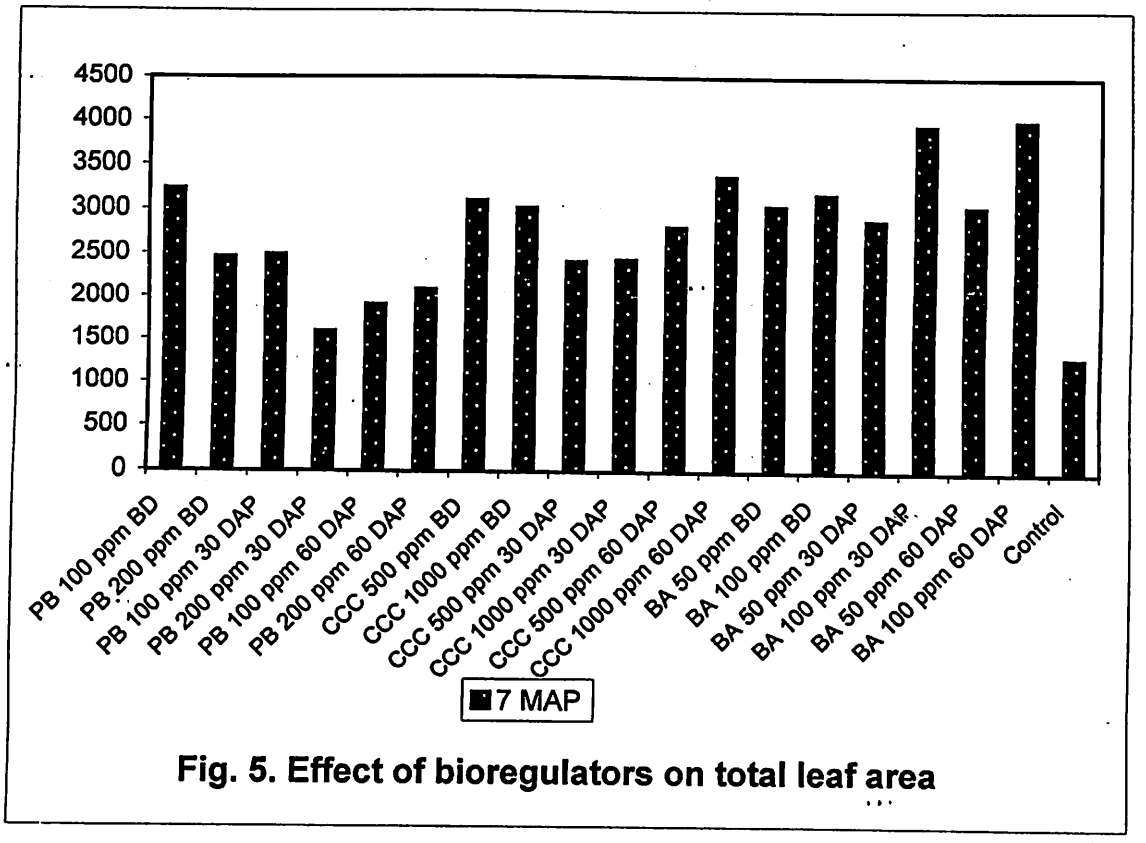


Fig. 5. Effect of bioregulators on total leaf area

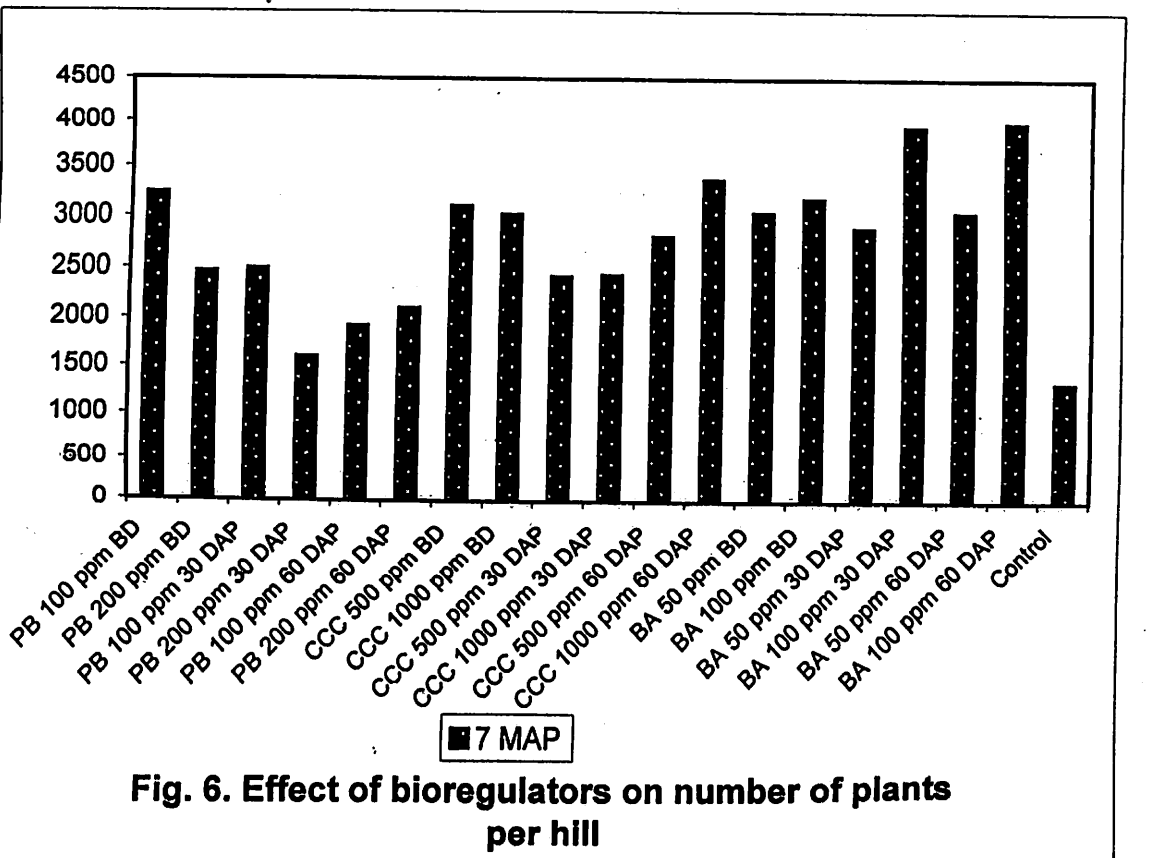


Fig. 6. Effect of bioregulators on number of plants per hill

Paclobutrazol - PB
Bulb dip - BD

applied as bulb dip (6.13). The tiller production was lowest in paclobutrazol 200 ppm applied 30 DAP. Significant increase in tiller production was observed in BA treatments applied 60 DAP when compared to control.

4.2 Floral characters

Data on the floral characters as influenced by various bio regulators are presented in Tables 10, 11, 12 and 13.

4.2.1 Days to first spike emergence

The days to first spike emergence showed significant variation among the treatments and also between treatments and control (Table 9). Earliest spike emergence was observed for paclobutrazol treatments, among which paclobutrazol at both the concentrations applied 60 DAP was the earliest (205.00 and 204.00 days respectively), followed by paclobutrazol 200 ppm bulb dip (210.20 days). The CCC treatments also registered earlier spike emergence as compared to control while the BA treatments resulted in longer time for spike emergence. Spike emergence was maximum delayed in BA 50 ppm and 100 ppm applied 60 DAP (244.50 and 245.50 days respectively). The control plants took 230.50 days for first spike emergence.

4.2.2 Days to first floret opening

Days to first floret opening differed significantly among the treatments. Earliest floret opening was observed in paclobutrazol 200 ppm applied 60 DAP (23.25 days) which was on par with CCC 500 applied 60 DAP (24.67 days). All the BA treatments registered delayed flowering of which the highest was BA

100 ppm applied 60 DAP (37.00 days). All the CCC treatments, in general, showed earlier floret opening as compared to control (Table 9).

4.2.3 Days to complete opening of florets

Time taken for complete opening of florets was lowest for paclobutrazol treatments, followed by CCC treatments (Table 9). The application of BA recorded more time for complete opening of florets as compared to control (20.82 days) with the maximum, for BA applied at flowering (23.00 days). Application of paclobutrazol at flowering reduced the time taken for complete opening of florets by 6.75 days than control.

4.2.4 Length of spike

All the bio regulator treatments resulted in the production of longer spikes as compared to control (73.90 cm). Bulb dip treatment of BA 50 ppm recorded the highest spike length (97.36 cm) which was on par with paclobutrazol 200 ppm applied 60 DAP (95.75 cm). This was followed by BA 50 ppm at flowering (88.50 cm). Longer spikes were produced by BA treatments, followed by CCC. Among the CCC treatments 500 ppm applied 60 DAP had longest spikes (84.51 cm)(Table 10).

4.2.5 Girth of spike

The girth of spike showed significant variation between treatments and control except for paclobutrazol treatments applied a bulb dip and 30 DAP. Paclobutrazol 200 ppm applied at flowering had maximum girth (2.81 cm) among paclobutrazol treatments. Among the CCC treatments 1000 ppm applied at

Table. 9. Effect of bio regulators on floral characters (Contd.)

Treatments	Days to first spike emergence	Days to first floret opening	Days to complete opening of florets (Days)
Paclobutrazol 100 ppm Bulb dip	215.50	32.00	18.25
Paclobutrazol 200 ppm Bulb dip	210.20	27.00	18.00
Paclobutrazol 100 ppm 30 DAP	212.50	27.50	17.85
Paclobutrazol 200 ppm 30 DAP	218.00	28.50	16.50
Paclobutrazol 100 ppm 60 DAP	205.00	25.00	14.00
Paclobutrazol 200 ppm 60 DAP	204.00	23.25	14.00
Paclobutrazol 100 ppm at Flowering	-	25.25	14.00
Paclobutrazol 200 ppm at Flowering	-	24.00	13.25
CCC 500 ppm Bulb dip	228.50	29.83	19.50
CCC 1000 ppm Bulb dip	220.87	28.66	19.00
CCC 500 ppm 30 DAP	218.50	28.25	19.85
CCC 1000 ppm 30 DAP	221.50	28.67	19.66
CCC 500 ppm 60 DAP	215.50	24.67	17.45
CCC 1000 ppm 60 DAP	217.67	25.00	17.50
CCC 500 pm at Flowering	-	26.08	17.98
CCC 1000 ppm at Flowering	-	25.25	17.00
BA 50 ppm Bulb dip	229.50	33.00	21.75
BA 100 ppm Bulb dip	232.80	36.25	21.25
BA 50 ppm 30 DAP	240.50	32.67	22.38
BA 100 ppm 30 DAP	244.20	32.00	22.00
BA 50 ppm 60 DAP	244.50	34.00	21.85
BA 100 ppm 60 DAP	245.50	37.00	22.44
BA 50 ppm at Flowering	-	36.50	23.00
BA 100 ppm at Flowering	-	36.85	23.00
Control	230.50	35.25	20.82
CD (0.05)	1.89	2.94	2.77
SEm ±	0.64	1.00	0.95

NS - Non significant

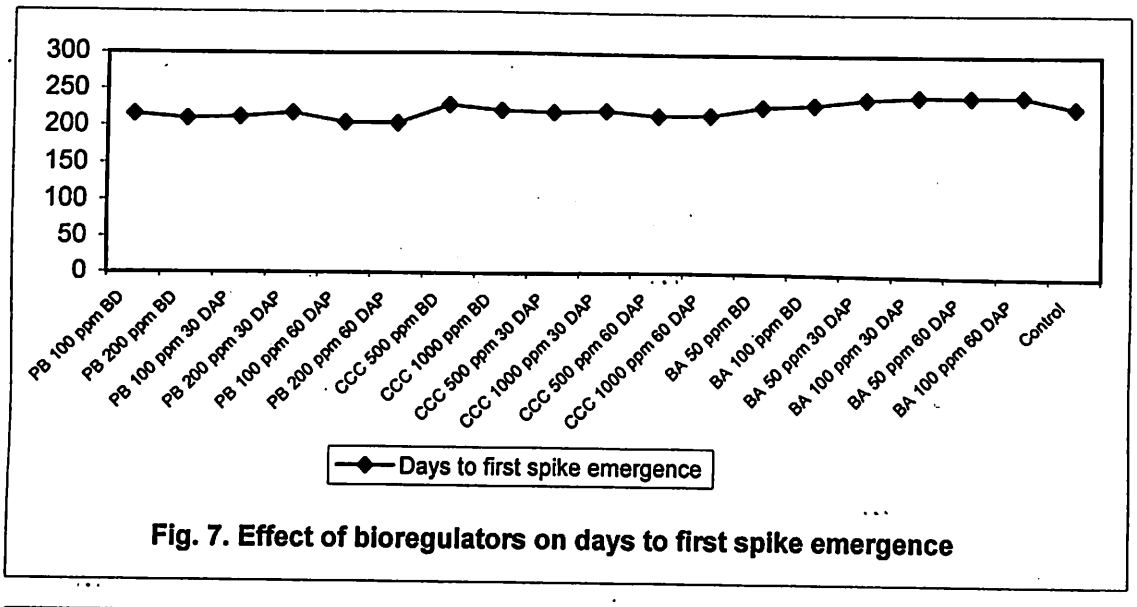


Fig. 7. Effect of bioregulators on days to first spike emergence

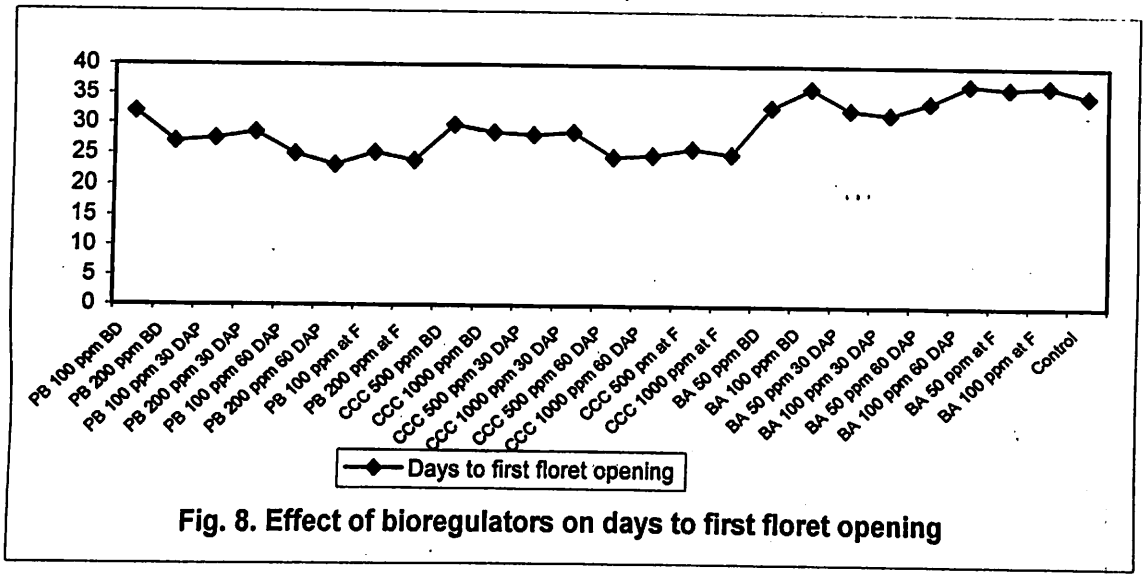


Fig. 8. Effect of bioregulators on days to first floret opening

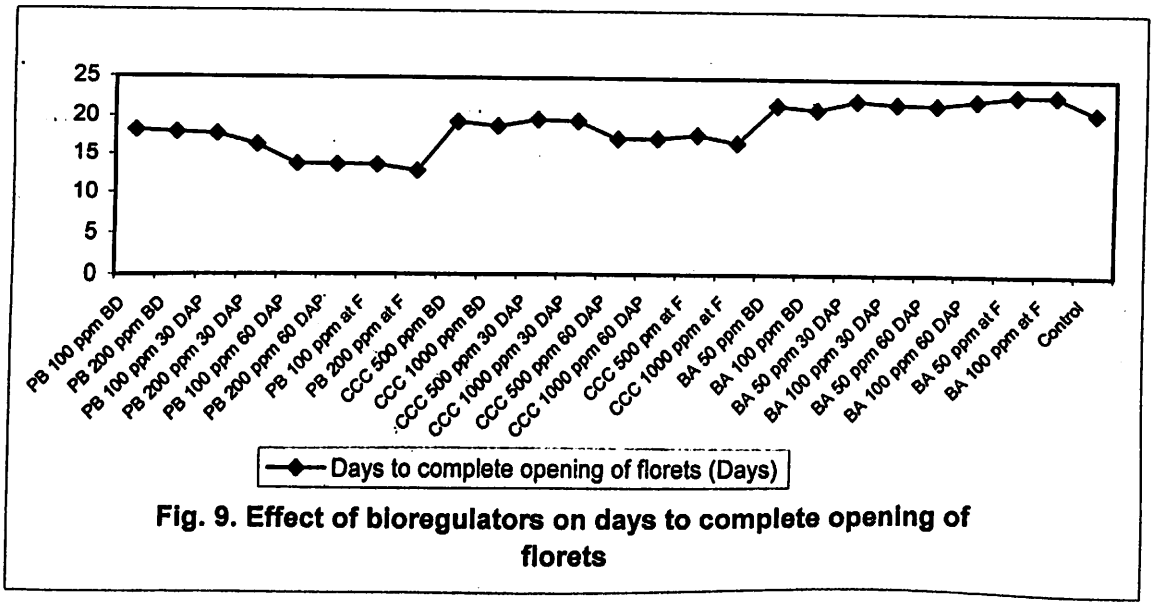


Fig. 9. Effect of bioregulators on days to complete opening of florets

Paclobutrazol - PB
Bulb dip - BD
At F - At flowering

Plate 3. Flowering in tuberose as influenced by paclobutrazol 100 ppm applied as bulb dip

Plate 4. Flowering in tuberose as influenced by paclobutrazol 200 ppm applied 30 DAP

Plate 5. Flowering in tuberose as influenced by paclobutrazol 200 ppm applied as bulb dip

Plate 3

Plate 4

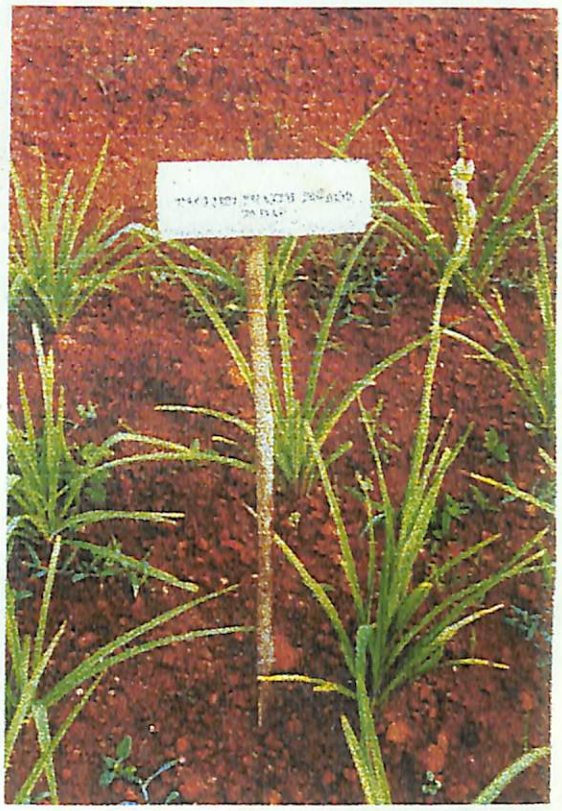


Plate 5

flowering registered maximum girth (2.97 cm), which was on par with the highest among all the treatments (2.98 cm), i.e., BA 50 ppm bulb dip.

4.2.6 Length of rachis

The data on the length of rachis as affected by various bio regulators are presented in Table 11.

Length of rachis showed significant variation among the treatments. Application of paclobutrazol 200 ppm at flowering registered highest rachis length (34.73 cm). This was found to be on par with CCC 1000 ppm applied 30 DAP (34.20 cm) and BA 50 ppm at flowering (33.13 cm), CCC 500 and 1000 ppm applied 60 DAP (32.26 cm and 32.16 cm).

Lowest mean rachis length was observed for CCC 500 ppm applied 30 DAP (20.69 cm) which was on par with control (23.10 cm). Paclobutrazol and BA applications, at flowering improved the rachis length. Application of CCC during the vegetative phase i.e., 30 DAP and 60 DAP resulted in increased rachis length. Among the bulb dip treatments, paclobutrazol 100 ppm (31.56 cm) and CCC 1000 ppm (30.35 cm) registered improvement in rachis length.

4.2.7 Number of florets per spike

Data on the number of florets per spike as influenced by bio regulators are presented in Table 11.

The number of florets per spike showed significant variation among treatments and between treatments and control. Highest number of florets were

Table.10. Effect of bio regulators on floral characters (Contd.)

Treatments	Length of spike (cm)			Girth of spike (cm)		
	1 week after	2 week after	3 week after	1 week after	2 week after	3 week after
Paclobutrazol 100 ppm Bulb dip	56.75	71.50	80.50	1.55	2.00	2.00
Paclobutrazol 200 ppm Bulb dip	50.25	75.25	78.25	1.45	2.07	2.07
Paclobutrazol 100 ppm 30 DAP	70.67	76.33	77.30	2.20	2.27	2.27
Paclobutrazol 200 ppm 30 DAP	74.08	79.00	79.71	2.00	2.15	2.20
Paclobutrazol 100 ppm 60 DAP	68.50	77.00	79.85	2.00	2.00	2.00
Paclobutrazol 200 ppm 60 DAP	70.50	91.25	95.75	2.45	2.55	2.55
Paclobutrazol 100 ppm at Flowering	53.50	67.83	77.165	2.03	2.36	2.43
Paclobutrazol 200 ppm at Flowering	56.83	73.43	81.00	2.46	2.68	2.81
CCC 500 ppm Bulb dip	56.23	71.83	80.33	2.17	2.58	2.61
CCC 1000 ppm Bulb dip	50.26	69.83	79.66	1.96	2.11	2.46
CCC 500 ppm 30 DAP	68.85	75.25	82.05	2.02	2.20	2.32
CCC 1000 ppm 30 DAP	63.33	71.83	78.00	1.80	1.95	2.25
CCC 500 ppm 60 DAP	57.83	82.00	84.51	2.41	2.48	2.45
CCC 1000 ppm 60 DAP	69.33	73.08	78.25	2.12	2.25	2.33
CCC 500 pm at Flowering	57.83	61.25	66.08	1.95	2.11	2.26
CCC 1000 ppm at Flowering	54.33	59.97	62.33	2.62	2.93	2.97
BA 50 ppm Bulb dip	76.10	94.66	97.36	2.80	2.95	2.98
BA 100 ppm Bulb dip	55.87	69.25	74.42	2.50	2.24	2.24
BA 50 ppm 30 DAP	56.77	67.83	77.00	2.05	2.28	2.48
BA 100 ppm 30 DAP	56.37	69.25	73.00	1.95	2.15	2.30
BA 50 ppm 60 DAP	59.23	73.5	84.58	2.20	2.40	2.41
BA 100 ppm 60 DAP	64.77	72.25	82.25	2.25	2.45	2.62
BA 50 ppm at Flowering	58.36	71.66	88.50	2.16	2.46	2.61
BA 100 ppm at Flowering	60.02	66.76	79.17	2.10	2.25	2.31
Control	47.86	67.00	73.90	1.30	2.03	2.03
CD (0.05)	5.17	6.64	8.39	0.37	0.28	0.23
SEm ±	1.77	2.28	2.88	0.13	0.09	0.81

NS - Non significant

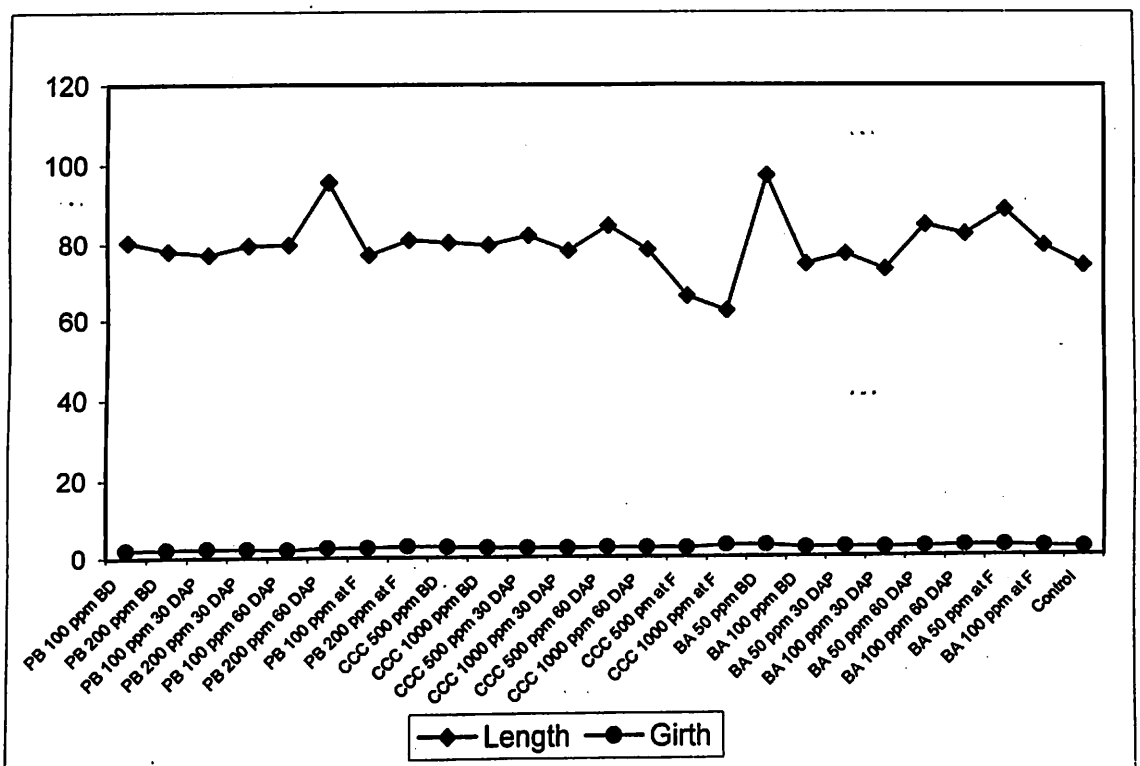


Fig. 10. Effect of bioregulators on length & girth of spike

Paclobutrazol - PB
Bulb dip - BD
At F - At flowering

Plate 6. Flowering in tuberose as influenced by BA 100 ppm applied 30 DAP

Plate 7. Flowering in tuberose as influenced by CCC 500 ppm applied as bulb dip

Plate 8. Flowering in control plots

Plate 6

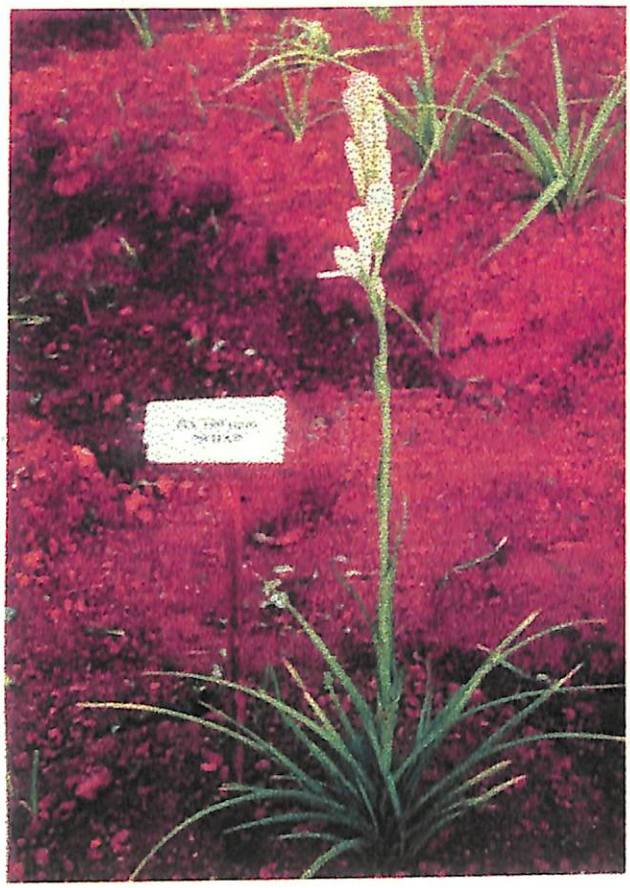
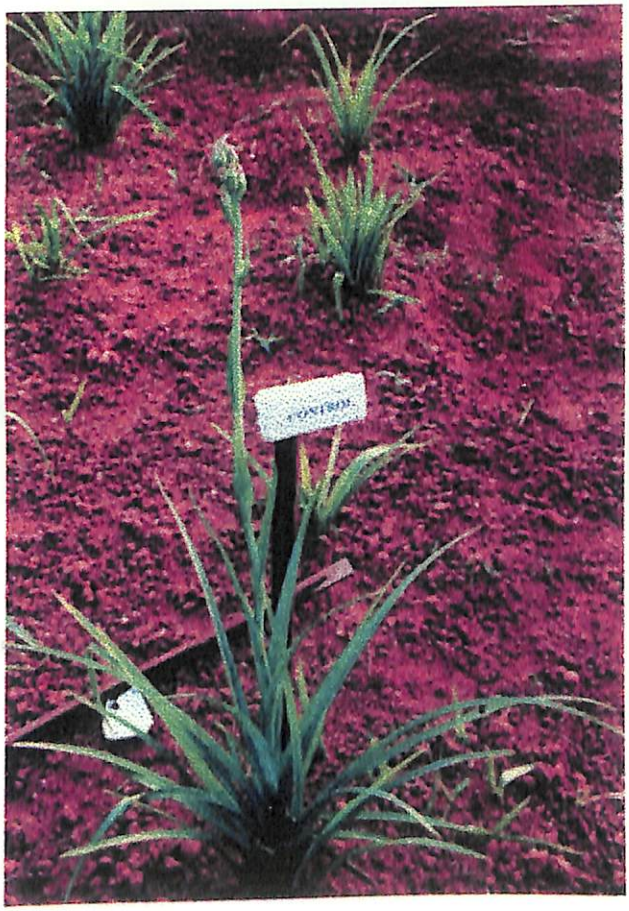


Plate 7

Plate 8



obtained for paclobutrazol 200 ppm applied as bulb dip (43.33), followed by paclobutrazol 100 ppm applied 30 DAP (42.00). All the paclobutrazol treatments showed improvement in the number of florets, except paclobutrazol 100 ppm applied 60 DAP). Among the CCC treatments also application of 500 ppm at bulb dip and 1000 ppm at 30 DAP excelled all other treatments. BA 100 ppm bulb dip was the best among BA treatments (41.33). This was followed by BA 100 ppm applied 30 DAP (40.83). BA treatments, in general showed improvement in the number of florets, when applied as bulb dip and at 30 DAP, while application at 60 DAP and flowering showed significantly lower number of florets as compared to control (33.83).

4.2.8 Size of floret

a) Length

Significant variation could be detected among treatments (Table 11). The highest floret length was observed for paclobutrazol 200 ppm applied at flowering (7.52 cm) and BA 50 ppm bulb dip (7.50 cm), which was found to be on par with CCC 1000 ppm 30 DAP, BA 50 ppm 30 DAP, 60 DAP and flowering and BA 100 ppm 60 DAP. Flower length was lower for all other paclobutrazol treatments, as compared to other bio regulator treatments, although they were on par with control (5.30 cm).

b) Breadth

The breadth of florets was found to be significantly influenced by application of bio regulators. All the treatments showed improvement in floret breadth as compared to control (2.93 cm). Paclobutrazol 200 ppm applied at

flowering (4.10 cm) and CCC 500 ppm (4.05 cm) and 1000 ppm (4.06 cm) applied 30 DAP recorded highest floral breadth.

4.2.9 Petiole length

A significant variation was noticed between different treatments (Table 12). Among paclobutrazol, CCC and BA, paclobutrazol gave the lesser petiole length when compared to CCC and BA. However, maximum length was noticed in BA 100 ppm applied 60 DAP (2.35 cm) which is on par with CCC 500 ppm applied 30 DAP (2.17 cm). Least length was given by paclobutrazol 200 ppm bulb dip and 200 ppm 60 DAP (0.40 cm).

4.2.10 Longevity of floret

The data on the longevity of floret as affected by different bio regulators are presented in Table 12. Wide variability was not observed in the longevity of floret. Among the different growth chemicals, maximum longevity was registered with BA when compared to paclobutrazol and CCC. Maximum longevity was detected with BA 50 ppm bulb dip, 60 DAP and flowering (2.50 days). Least longevity was noticed with paclobutrazol 100 ppm bulb dip and control (1.16 days) which is on par with CCC 500 ppm bulb dip and CCC 1000 ppm applied at 30 DAP (1.33 days).

4.2.11 Longevity of spike in the field

The data given in the Table 12 revealed that there exists a significant variation in the longevity of spike with the application of growth chemicals. Least days was given by BA 100 ppm bulb dip (17.33 days) which is followed by both

Table 11. Effect of bio regulators on floral characters (Contd.)

Treatments	Length of rachis (cm)	Number of florets per spike	Size of floret (cm)	
			Flower length (cm)	Flower breadth (cm)
Paclobutrazol 100 ppm Bulb dip	31.56	36.33	5.45	3.97
Paclobutrazol 200 ppm Bulb dip	21.05	43.33	5.56	3.56
Paclobutrazol 100 ppm 30 DAP	25.08	42.00	6.68	4.07
Paclobutrazol 200 ppm 30 DAP	22.81	37.16	5.62	3.76
Paclobutrazol 100 ppm 60 DAP	22.66	29.33	6.45	2.05
Paclobutrazol 200 ppm 60 DAP	21.00	36.50	5.35	3.32
Paclobutrazol 100 ppm at Flowering	24.31	38.18	5.45	3.95
Paclobutrazol 200 ppm at Flowering	34.73	37.83	7.52	4.10
CCC 500 ppm Bulb dip	25.58	38.66	6.97	3.88
CCC 1000 ppm Bulb dip	30.35	35.83	6.96	3.10
CCC 500 ppm 30 DAP	20.69	35.00	6.47	4.05
CCC 1000 ppm 30 DAP	34.20	37.83	7.36	4.06
CCC 500 ppm 60 DAP	32.26	30.16	5.96	3.50
CCC 1000 ppm 60 DAP	32.16	36.83	6.38	3.95
CCC 500 pm at Flowering	21.75	29.50	5.45	3.95
CCC 1000 ppm at Flowering	20.80	34.67	5.10	3.63
BA 50 ppm Bulb dip	23.55	32.00	7.50	3.71
BA 100 ppm Bulb dip	22.33	41.33	6.62	3.44
BA 50 ppm 30 DAP	23.08	39.33	6.60	3.97
BA 100 ppm 30 DAP	26.16	40.83	6.85	3.42
BA 50 ppm 60 DAP	25.47	27.00	7.23	3.33
BA 100 ppm 60 DAP	20.23	26.50	7.30	3.97
BA 50 ppm at Flowering	33.13	30.50	7.20	3.92
BA 100 ppm at Flowering	24.58	29.83	6.95	2.07
Control	23.10	33.83	5.30	2.93
CD (0.05)	2.70	1.52	0.47	0.21
SEm ±	0.93	0.52	0.16	0.07

NS - Non significant

Plate 9. Influence of bio regulator on rachis length

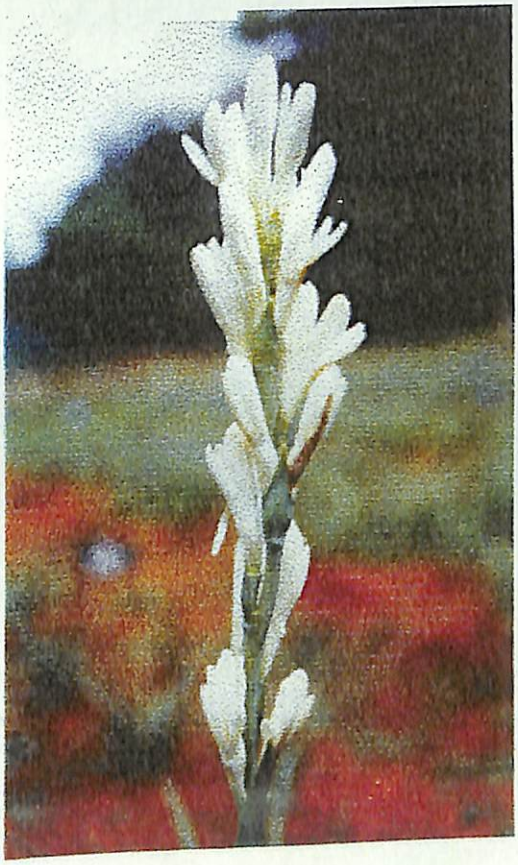
Plate 10. Influence of bio regulator on longevity of florets

Plate 11. Influence of bio regulator on complete opening of florets

Plate 9

Plate 10

Plate 11



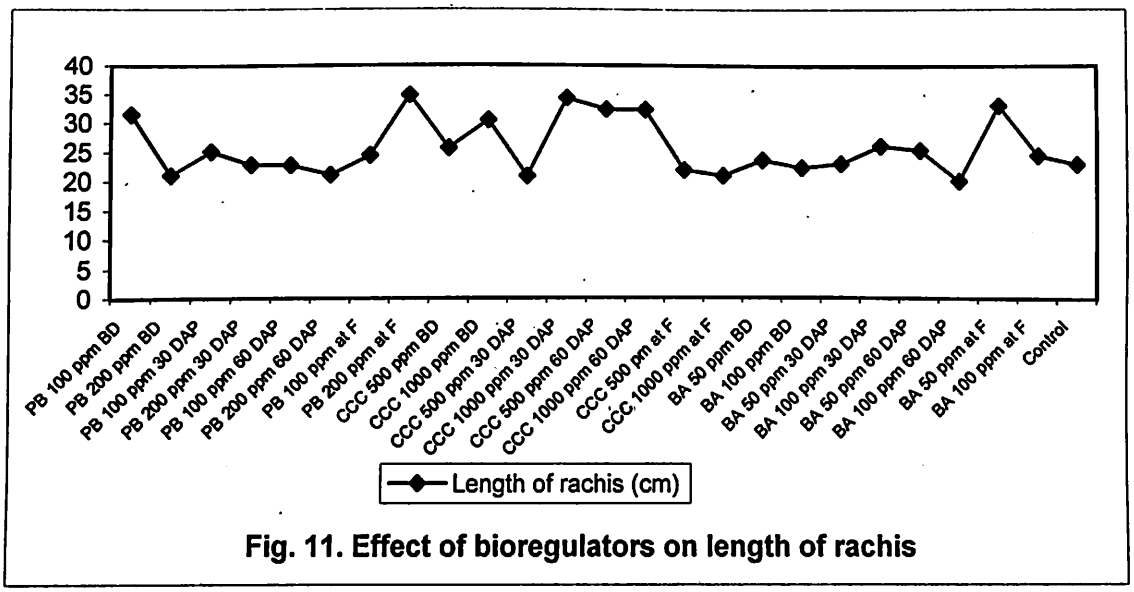


Fig. 11. Effect of bioregulators on length of rachis

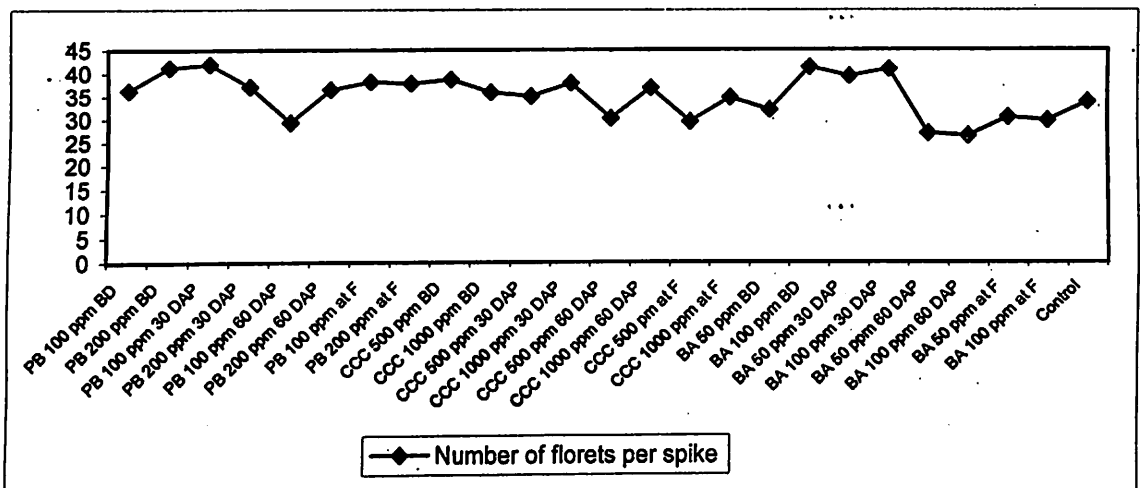


Fig. 12. Effect of bioregulators on number of florets per spike

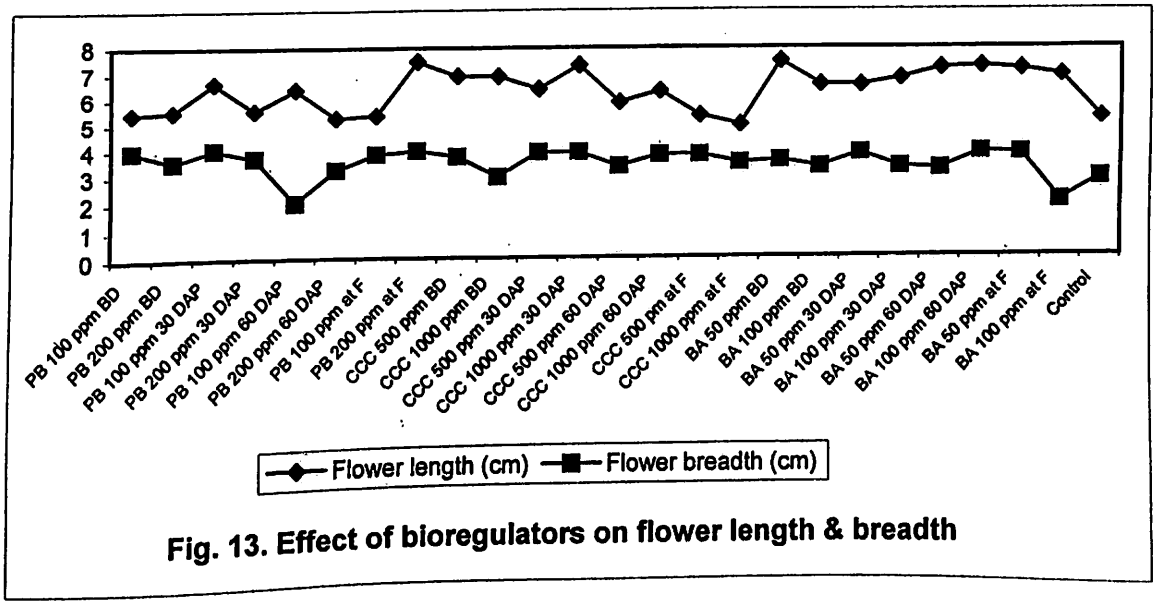


Fig. 13. Effect of bioregulators on flower length & breadth

Paclobutrazol - PB
Bulb dip - BD
At F - At flowering

levels of paclobutrazol bulb dip (20.25 and 20.83 days) respectively. In comparison to control, best result was given by paclobutrazol 100 ppm applied at 60 DAP (42.50 days).

4.2.12 Yield of spike per hill

It is apparent from the data that not much significant variation was there in the yield of spike with the application of growth chemicals. BA bulb dip treatments gave the maximum number of spike in comparison to all other treatments (1.65) which is on par with BA 50 ppm applied at 30 DAP (1.67). Almost all other treatment gave the same result as that of control (1.00).

4.2.13 Vase life

Among paclobutrazol, CCC and BA treatments, CCC gave the maximum vase life when compared to paclobutrazol and BA. Vase life was found to be maximum with CCC 1000 ppm bulb dip (11.64 days) which is on par with CCC 500 ppm 60 DAP (11.32 days). Least vase life was recorded with paclobutrazol 100 ppm applied 30 DAP (7.05 days) which is on par with BA 50 ppm 30 DAP (7.16 days) and control (7.15 days).

4.3 Bulb characters

Data on the bulb characters as influenced by bio regulators presented in Table 13 and 14.

4.3.1 Size of bulbs

None of the bio regulators except BA 50 ppm at flowering showed improvement in bulb size. Application of BA 50 ppm at flowering stage, increased

Table 12. Effect of bio regulators on floral characters (Contd.)

Treatments	Petiole length (cm)	Longevity of floret (days)	Longevity of spike in field (days)	Yield of spike per hill	Vase life (days)
Paclobutrazol 100 ppm Bulb dip	0.67	1.16	20.25	1.33	8.82
Paclobutrazol 200 ppm Bulb dip	0.40	1.83	20.83	1.16	7.50
Paclobutrazol 100 ppm 30 DAP	1.43	1.83	27.33	1.00	7.05
Paclobutrazol 200 ppm 30 DAP	0.55	2.16	31.00	1.00	10.05
Paclobutrazol 100 ppm 60 DAP	0.70	2.50	42.50	1.00	9.50
Paclobutrazol 200 ppm 60 DAP	0.40	2.33	28.25	1.00	8.00
Paclobutrazol 100 ppm at Flowering	0.83	2.16	33.66	1.00	10.84
Paclobutrazol 200 ppm at Flowering	1.47	2.00	32.33	1.00	11.05
CCC 500 ppm Bulb dip	0.61	1.33	35.16	1.33	11.00
CCC 1000 ppm Bulb dip	1.55	1.50	34.00	1.16	11.64
CCC 500 ppm 30 DAP	2.17	2.50	26.25	1.16	7.50
CCC 1000 ppm 30 DAP	1.86	1.33	29.16	1.33	8.44
CCC 500 ppm 60 DAP	0.53	1.83	25.16	1.00	11.32
CCC 1000 ppm 60 DAP	1.41	2.33	33.08	1.00	7.56
CCC 500 pm at Flowering	0.45	1.67	26.50	1.00	10.61
CCC 1000 ppm at Flowering	0.40	1.50	24.33	1.00	9.56
BA 50 ppm Bulb dip	2.07	2.50	27.00	1.65	8.56
BA 100 ppm Bulb dip	1.47	1.00	17.33	1.65	7.48
BA 50 ppm 30 DAP	0.80	1.33	30.16	1.67	7.16
BA 100 ppm 30 DAP	1.85	1.16	21.50	1.33	7.58
BA 50 ppm 60 DAP	1.19	2.50	29.66	1.00	7.94
BA 100 ppm 60 DAP	2.35	1.50	28.25	1.00	7.68
BA 50 ppm at Flowering	1.50	2.50	35.33	1.00	9.99
BA 100 ppm at Flowering	1.66	2.33	32.16	1.00	9.84
Control	1.00	1.16	27.50	1.00	7.15
CD (0.05)	0.24	0.44	4.82	0.21	2.21
SEm ±	0.08	0.15	1.66	0.07	0.94

NS - Non significant

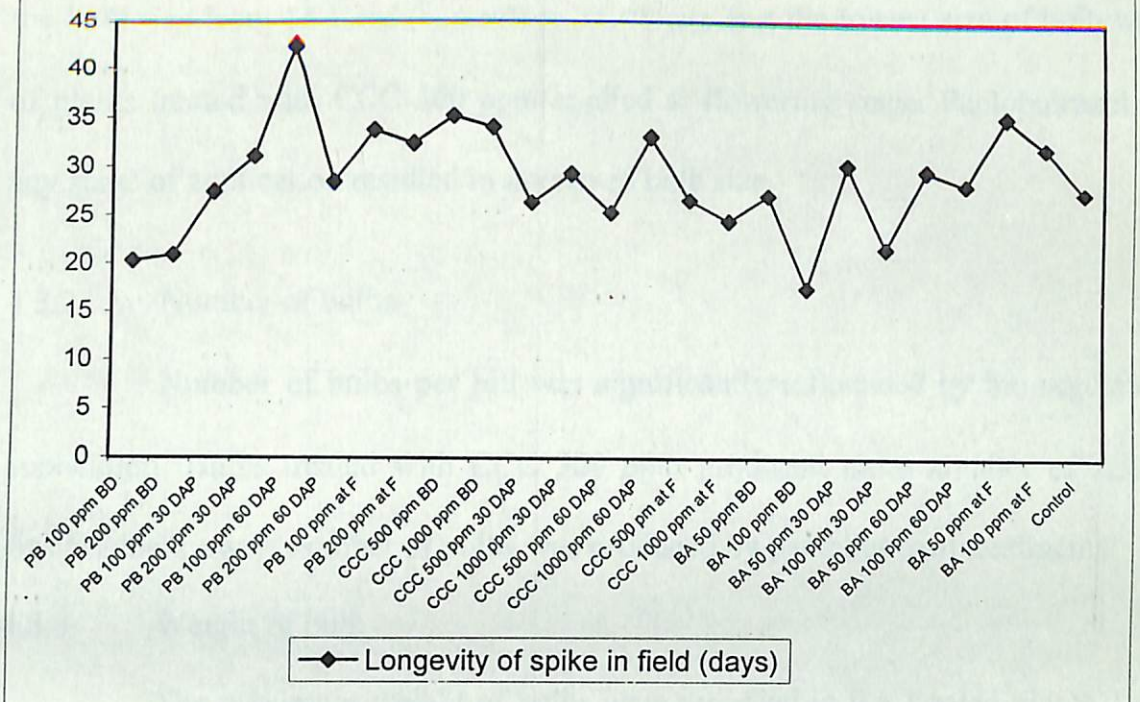


Fig. 14. Effect of bioregulators on longevity of spike in the field

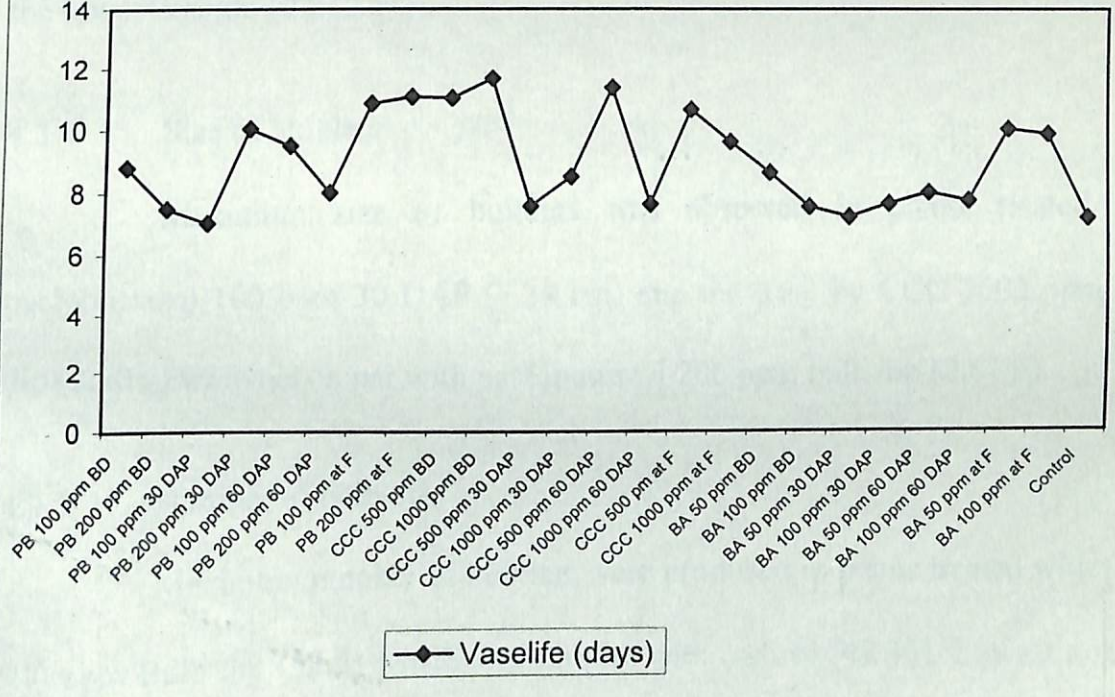


Fig. 15. Effect of bioregulators on vase life

Paclobutrazol - PB
Bulb dip - BD
At F - At flowering

the bulb size from 15.1 cm (control) to 16.08 cm. But the lowest size of bulb was of plants treated with CCC 500 ppm applied at flowering stage. Paclobutrazol at any stage of application resulted in improved bulb size.

4.3.2 Number of bulbs

Number of bulbs per hill was significantly influenced by bio regulator application. Bulbs treated with CCC 500 ppm produced more number of small sized bulbs. Lowest number of bulbs was produced by paclobutrazol treatments.

4.3.3 Weight of bulb

The maximum weight of bulbs were recorded in BA treated plants, i.e., bulbs treated with BA 50 ppm 60 DAP recorded 121.00 g as compared to 29.48 g in control. Application of CCC 500 ppm applied at 30 DAP resulted in bulbs with the lowest weight (22.42 g).

4.3.4 Size of bulblets

Maximum size of bulblets was observed in plants treated with paclobutrazol 100 ppm 30 DAP (7.24 cm) and the least by CCC 1000 ppm bulb dip (2.60 g) which is on par with paclobutrazol 200 ppm bulb dip (2.61 g).

4.3.5 Number of bulblets

Maximum number of bulblets were produced in plants treated with CCC 500 ppm Bulb dip (52.5) which was on pan with control (48.33). Lowest number of bulblets were produced in plots treated with BA 100 ppm given as bulb dip which was par with paclobutrazol 200 ppm given as bulb dip (10.66).

Table 13. Effect of bio regulators on bulb characters

Treatments	Size of bulb (cm)	Number of bulb	Weight of bulbs(g)
Paclobutrazol 100 ppm Bulb dip	12.87	1.00	41.76
Paclobutrazol 200 ppm Bulb dip	11.18	1.00	37.20
Paclobutrazol 100 ppm 30 DAP	14.65	1.00	43.09
Paclobutrazol 200 ppm 30 DAP	14.18	1.33	71.29
Paclobutrazol 100 ppm 60 DAP	13.96	1.00	53.85
Paclobutrazol 200 ppm 60 DAP	11.67	1.00	28.79
Paclobutrazol 100 ppm at Flowering	8.95	2.67	27.71
Paclobutrazol 200 ppm at Flowering.	12.52	2.00	58.55
CCC 500 ppm Bulb dip	6.90	8.00	76.95
CCC 1000 ppm Bulb dip	11.27	2.67	43.62
CCC 500 ppm 30 DAP	9.43	1.00	22.42
CCC 1000 ppm 30 DAP	11.99	1.67	57.49
CCC 500 ppm 60 DAP	8.45	1.00	14.21
CCC 1000 ppm 60 DAP	9.44	3.33	62.18
CCC 500 pm at Flowering	6.28	2.00	33.11
CCC 1000 ppm at Flowering	10.94	3.00	88.40
BA 50 ppm Bulb dip	8.58	2.67	45.83
BA 100 ppm Bulb dip	12.21	1.00	35.18
BA 50 ppm 30 DAP	11.23	1.33	41.35
BA 100 ppm 30 DAP	12.78	1.33	47.09
BA 50 ppm 60 DAP	12.73	3.83	121.00
BA 100 ppm 60 DAP	11.10	1.67	44.09
BA 50 ppm at Flowering	16.08	1.00	68.23
BA 100 ppm at Flowering	12.87	2.00	59.36
Control	15.10	1.00	29.48
CD (0.05)	1.64	0.09	4.76
SEm ±	0.56	0.03	1.64

NS - Non significant

Plate 12. Effect of bio regulators on bulb size

Plate 13. Effect of bio regulators on bulb size

Plate 14. Effect of bio regulators on bulb size

Plate 15. Effect of bio regulators on bulblet size

Plate 16. Effect of bio regulators on bulblet size

Plate 12

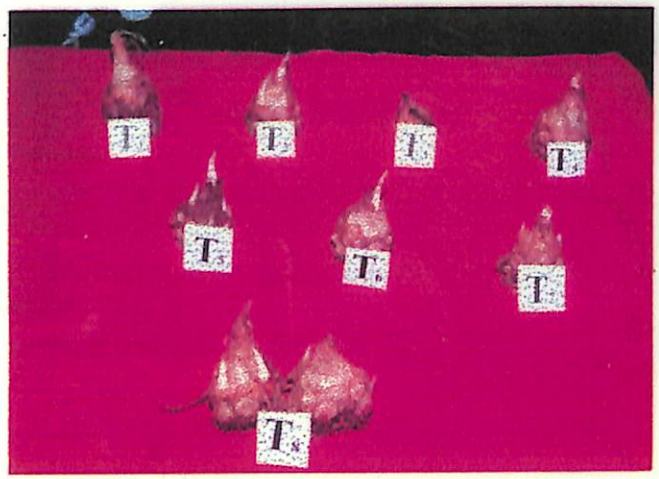


Plate 13

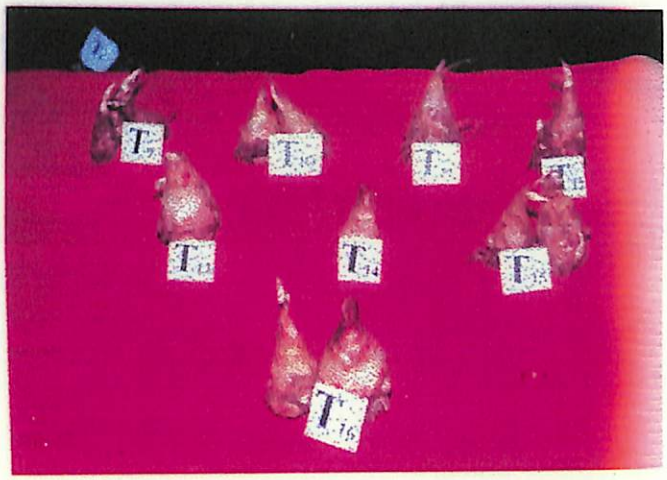


Plate 14

Plate 15

Plate 16

4.3.6 Weight of bulblets

Maximum weight of bulblets was observed in BA 50 ppm treated bulbs (128.75 g). Which was on par with application of BA 50 ppm at flowering (113.86 g) control (114.17 g) CCC 1000 ppm 60 DAP (107.43 g). Least weight of bulblets were recorded in BA 100 ppm bulb dip (20.51 g) which is on par with paclobutrazol 200 ppm applied 60 DAP (32.71 g), CCC 500 ppm 30 DAP (32.44 g), CCC 500 ppm flowering (36.19 g), CCC 1000 ppm bulb dip (42.50 g) and paclobutrazol 200 ppm bulb dip (45.70 g).

4.4 Post harvest experiments

4.4.1 Effect of pulsing treatment

Data pertaining the effect of different pulsing treatments on the post harvest life of spikes are given in the Table 15.

4.4.1.1 Days for opening of each floret

None of the pulsing treatments significantly influenced the number of days for opening of each floret during the experiment.

4.4.1.2 Days for complete opening of florets

This particular character was significantly influenced by pulsing treatments. Treatment with 8 HQS 250 ppm (10 days) recorded maximum days which was an par with $AgNO_3$ 50 ppm and 100 ppm (9.67 days) while sucrose 10 per cent (8.67 days) took lowest number of days for complete opening of florets.

Table 14. Effect of bio regulators on bulblet characters

Treatments	Size of bulblet (cm)	Number of bulblet	Weight of bulblet (g)
Paclobutrazol 100 ppm Bulb dip	4.62	14.66	65.92
Paclobutrazol 200 ppm Bulb dip	3.79	10.66	45.70
Paclobutrazol 100 ppm 30 DAP	7.24	13.17	84.60
Paclobutrazol 200 ppm 30 DAP	4.25	26.00	56.43
Paclobutrazol 100 ppm 60 DAP	5.11	20.33	70.03
Paclobutrazol 200 ppm 60 DAP	2.61	19.02	32.71
Paclobutrazol 100 ppm at Flowering	4.74	35.67	103.55
Paclobutrazol 200 ppm at Flowering	4.19	21.50	48.80
CCC 500 ppm Bulb dip	4.29	52.50	86.65
CCC 1000 ppm Bulb dip	2.60	27.33	42.50
CCC 500 ppm 30 DAP	4.36	15.83	32.44
CCC 1000 ppm 30 DAP	4.98	33.67	80.32
CCC 500 ppm 60 DAP	4.91	13.33	39.88
CCC 1000 ppm 60 DAP	4.64	42.66	107.43
CCC 500 pm at Flowering	4.63	14.33	36.19
CCC 1000 ppm at Flowering	5.11	33.50	77.62
BA 50 ppm Bulb dip	3.05	48.83	128.75
BA 100 ppm Bulb dip	3.70	7.83	20.51
BA 50 ppm 30 DAP	5.10	15.33	67.51
BA 100 ppm 30 DAP	4.96	17.17	42.36
BA 50 ppm 60 DAP	6.29	27.16	68.11
BA 100 ppm 60 DAP	4.62	35.33	94.49
BA 50 ppm at Flowering	5.82	35.33	113.86
BA 100 ppm at Flowering	3.35	19.00	45.27
Control	6.13	48.33	114.17
CD (0.05)	0.73	4.09	27.04
SEm ±	0.25	1.41	9.29

NS - Non significant

4.4.1.3 Number of florets opened at a time

The number of florets opened at a time was not significantly influenced by pulsing treatments.

4.4.1.4 Total water uptake

Effect of pulsing treatments on the quantity of water uptake by the spikes was found to be significant. Maximum was recorded when pulsed with $AgNO_3$ 100 ppm (24.66 ml) and minimum with 8 HQS 250 ppm (10.13 ml).

4.4.1.5 Vase life

Maximum vase life was given by the pulsing treatment with $AgNO_3$ 50 ppm (8.66 days) which is on par with 8 HQS 250 ppm (8.33 days) and minimum with sucrose 10 per cent (5.67 days).

4.4.1.6 Electrolyte leakage

The difference between various pulsing treatment was found to be significant with respect to electrolyte leakage. Maximum leakage was noticed in pulsing with $AgNO_3$ 100 ppm (0.036 ms g^{-1}) and minimum –0.04 ms g^{-1} with $AgNO_3$ 100 ppm.

4.4.2 Effect of Pulsing and Holding Solutions

4.4.2.1 Fresh weight of the spike

Maximum fresh weight of the spike was observed in the interaction of pulsing with sucrose 15 per cent and holding solution 4 per cent (64.38 g). Minimum weight was in sucrose 15 per cent 8 HQS 200 ppm (24.71 g) which was

Table 15. Standardization of pulsing solution in tuberose

Treatments	Fresh weight of the spike (gm)	Time taken for opening of each floret (days)	Time taken for complete opening of florets (days)	Number of florets opened at a time	Total water uptake (ml)	Vase life (days)	EC (m Sg^{-1})
Sucrose 10%	42.21	1.00	8.67	2.67	10.16	5.67	0.01
Sucrose 15%	32.15	1.33	9.67	2.67	10.46	6.66	0.10
8 HQS 250 ppm	52.03	1.00	10.00	1.67	10.13	8.33	0.01
8 HQS 500 ppm	44.89	1.00	9.00	2.67	10.70	7.00	0.02
$AgNO_3$ 50 ppm	34.89	1.67	9.67	2.00	17.30	8.66	-0.01
$Ag\ NO_3$ 100 ppm	35.96	1.67	9.67	2.67	24.66	7.33	-0.04
Control	45.15	1.33	8.67	1.33	10.12	5.66	0.00
CD	40.35	NS	0.83	NS	3.23	0.92	0.00

NS - Non significant

followed by sucrose 15 per cent and 8 HQS 400 ppm (28.64 g) and sucrose 15 per cent and $AgNO_3$ 0.25 mM (28.16 m).

4.4.2.2 Days for opening of each floret

The treatments significantly influenced the days for opening of each floret in vase (Table 18). Control treatments with tap water and distilled water took 2 and 1.67 days respectively. Maximum number of days recorded by 8 HQS 500 ppm and 8 HQS 400 ppm (3.00 days), $AgNO_3$ 50 ppm and 8 HQS 200 ppm, $AgNO_3$ 100 ppm and 8 HQS 200 ppm (2.67 days) and minimum with sucrose 10 per cent and sucrose 4 per cent, 8 HQS 250 ppm and $AgNO_3$ 0.50 mM (1 day) which was lesser than control.

4.4.2.3 Days to complete opening of florets

Effects of treatments on the days to complete opening of florets was found to be significant. Maximum days taken for the complete opening of florets was $AgNO_3$ 100 ppm and sucrose 2 per cent (17.33 days) which was followed by sucrose 10 per cent and $AgNO_3$ 0.25 mM (17 days). Least number of day was registered for 8 HQS 200 ppm and sucrose 10 per cent (9 days). Tap water and distilled water took 15.6 and 16 days respectively.

4.4.2.4 Number of florets opened at a time

Table 20 deals with the observations on the number of florets that remained open at a time when they are retained in the vase in various holding solutions.

Table 16. Fresh weight of the spike (g) as influenced by combinations of pulsing and holding solutions

Holding treatments	Pulsing treatments						
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	Mean
Sucrose 2%	44.95	44.56	42.21	37.07	52.52	31.88	42.20
Sucrose 4%	38.56	64.38	34.88	53.75	55.36	42.64	48.26
8HQS 200 ppm	55.94	24.71	32.15	53.04	56.03	38.53	43.40
8HQS 400 ppm	57.07	28.64	35.96	36.12	45.07	43.21	41.01
$AgNO_3$ 0.25 mM	41.78	28.16	52.03	58.27	53.36	35.88	43.24
$AgNO_3$ 0.50 mM	43.26	47.32	44.88	58.61	43.34	42.78	46.70
Mean	46.92	39.63	40.35	49.47	49.28	39.15	

CD for comparison of P (or H) = 11.47
CD for comparison of P x H = 9.76

Table 17. Time taken for opening of each floret (days) as influenced by combinations of pulsing and holding solutions

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	1.66	1.66	1.66	1.66	1.66	2.00	1.72
Sucrose 4%	1.00	1.66	2.00	1.33	1.66	2.33	1.66
8HQS 200 ppm	2.33	1.66	2.33	2.33	2.66	2.66	2.33
8HQS 400 ppm	1.33	2.00	2.66	3.00	2.00	1.33	2.05
$AgNO_3$ 0.25 mM	2.33	1.33	1.66	2.66	1.60	1.66	1.88
$AgNO_3$ 0.50 mM	1.66	1.33	1.00	1.66	2.33	1.66	1.61
Mean	1.72	1.61	1.88	2.11	2.00	1.94	

CD for comparison of P (or H) = 0.55
CD for comparison of P x H = 0.895

Table 18. Time taken for complete opening of florets (days) as influenced by combinations of pulsing and holding treatments.

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	10.33	15.33	14.66	12.33	16.33	17.33	14.38
Sucrose 4%	16.33	12.66	14.00	16.33	15.33	14.66	14.88
8HQS 200 ppm	9.00	12.66	15.33	13.33	12.33	10.66	12.22
8HQS 400 ppm	15.66	14.66	16.66	15.33	16.33	14.33	15.5
$AgNO_3$ 0.25 mM	17.00	16.33	16.66	14.66	15.33	14.66	15.70
$AgNO_3$ 0.50 mM	12.66	15.33	15.33	10.66	13.33	15.33	13.77
Mean	13.50	14.5	15.44	13.77	14.83	14.50	

CD for comparison of P (or H) = 2.14
CD for comparison of P x H = 1.48

Among the different treatments, the effect of sucrose 10 per cent and 8 HQS 400 ppm, sucrose 15 per cent and sucrose 4 per cent in increasing the number of florets opened at a time was clearly evident. Maximum number of florets opened at a time (8.33) was recorded with the above given treatments. Minimum number of florets opened at a time (1.33) was recorded with control.

4.4.2.5 Total water uptake

The influence of various treatments on the total water uptake by the spike in the vase was found to be significant. Maximum uptake was recorded in spikes treated with sucrose 10 per cent and $AgNO_3$ 0.25 mM (50.2ml) and the least uptake was in 8 HQS 500 ppm and 8 HQS 400 ppm (5.36 ml) which was on par with 8 HQS 500 ppm and $AgNO_3$ 0.25 mM and sucrose 10 per cent and sucrose 4 per cent (5.6 ml).

4.4.2.6 Vase life

Data pertaining to the results of the vase life of the spikes in different pulsing and holding solution are given in Table 21.

Maximum vase life was given by $AgNO_3$ 50 ppm pulsing and put in holding solution containing $AgNO_3$ 0.25 mM (13.667 days) which is followed by $AgNO_3$ 500 ppm and 8 HQS 400 ppm and $AgNO_3$ 50 ppm and sucrose 2 per cent (13.33 days). Vase life was much reduced in sucrose 10 per cent and 8 HQS 200 ppm and $AgNO_3$ 100 ppm and $AgNO_3$ 0.25 mM (6.33 days). With control tap water the vase life was 6 days and with distilled water, the vase life was 6.6 days.

Table 19. Number of florets opened at a time as influenced by combinations of pulsing and holding solutions.

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	5.66	2.00	3.33	7.00	6.33	3.33	4.61
Sucrose 4%	7.66	8.33	2.66	2.33	2.66	2.33	4.33
8HQS 200 ppm	5.33	2.66	2.33	3.33	1.66	1.66	2.83
8HQS 400 ppm	8.33	1.66	2.00	3.66	2.33	2.00	3.33
$AgNO_3$ 0.25 mM	3.33	3.33	2.33	2.66	1.66	1.00	2.38
$AgNO_3$ 0.50 mM	3.33	4.33	2.66	1.66	4.33	2.66	3.16
Mean	5.61	3.72	2.55	3.44	3.16	2.16	

CD for comparison of P (or H) = 1.98
CD for comparison of P x H = 1.18

Table 20. Total water uptake (ml) as influenced by combinations of pulsing and holding solutions.

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	15.33	29.03	10.36	10.80	29.13	35.36	21.67
Sucrose 4%	5.60	50.83	10.73	10.76	19.53	29.16	21.10
8HQS 200 ppm	29.36	10.50	10.13	10.13	40.58	15.26	20.21
8HQS 400 ppm	21.03	20.36	5.36	5.36	41.43	20.96	19.96
$AgNO_3$ 0.25 mM	50.20	30.40	5.60	5.60	10.43	28.03	22.18
$AgNO_3$ 0.50 mM	20.73	12.60	15.46	15.46	10.53	27.03	15.41
Mean	23.71	25.62	9.68	9.68	25.27	25.97	

CD for comparison of P (or H) = 13.89
CD for comparison of P x H = 0.63

Table 21. Vase life (Days) as influenced by combinations of pulsing and holding solutions.

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	7.33	11.33	11.33	8.33	13.33	11.33	10.50
Sucrose 4%	12.00	8.33	10.33	12.33	12.66	12.67	11.38
8HQS 200 ppm	6.66	9.66	11.33	10.66	6.33	8.33	8.83
8HQS 400 ppm	10.33	10.66	9.66	8.66	13.33	6.66	9.88
$AgNO_3$ 0.25 mM	12.66	12.66	10.67	9.66	13.66	9.33	11.44
$AgNO_3$ 0.50 mM	10.66	12.00	11.33	6.66	12.66	9.66	10.50
Mean	9.94	10.77	10.77	9.38	12.00	9.66	

CD for comparison of P (or H) = 2.35
CD for comparison of P x H = 1.198

4.4.2.7 Electrolyte leakage

Electrical conductivity of the vase solution was measured and given in the Table 22.

Minimum leakage was recorded with 8 HQS 500 ppm and 8 HQS 400 ppm (0.002 in m S g^{-1}) which was on par with sucrose 15 per cent and $AgNO_3$ 0.50 mM (0.003 m S g^{-1}). Maximum was with 8 HQS 250 ppm and $AgNO_3$ 0.50 mM (0.100 m S g^{-1}). Tap water recorded the electrical conductivity as 0.074 and distilled water as 0.080 m S g^{-1}.

Table 22. Electrical conductivity (m S g^{-1}) as influenced by combinations of pulsing and holding solutions.

Holding treatments	Pulsing treatments						Mean
	Sucrose 10%	Sucrose 15%	8HQS 250 ppm	8HQS 500 ppm	$AgNO_3$ 50 ppm	$AgNO_3$ 100 ppm	
Sucrose 2%	0.007	-0.007	0.072	0.053	0.006	0.017	0.025
Sucrose 4%	0.008	0.019	0.013	0.002	0.007	0.020	0.011
8HQS 200 ppm	0.012	0.041	0.020	0.007	0.078	-0.005	0.025
8HQS 400 ppm	0.014	0.017	0.041	0.002	0.014	0.057	0.024
$AgNO_3$ 0.25 mM	-0.013	0.025	0.043	0.009	0.023	-0.050	0.006
$AgNO_3$ 0.50 mM	0.012	0.003	0.100	0.009	0.013	-0.037	0.017
Mean	0.007	0.016	0.048	0.014	0.024	0.000	

CD for comparison of P (or H) = 0.03
CD for comparison of P x H = 0.00013

DISCUSSION

DISCUSSION

Results generated from the studies conducted to examine the effect of bio regulators on morphological and floral characters of tuberose are discussed here under.

In the orient, where 'white' goes for virtue and purity, tuberose is much more adorned for its colour and fragrance. Among the commercially grown flowers in India, tuberose (*Polianthes tuberosa* L.) occupies a prime position because of its popularity as cut flower, loose flower as well as for its potential in perfume industry (Maiti, 1999). The present experiments were aimed at studying the effect of certain bio regulants like paclobutrazol, CCC and BA on tuberose cv. Double which is mainly used as cut flower. Standardization of pulsing and holding solution formed part of the study. The flowering and yield of any crop is a reflection of its growth during the pre flowering stage. In a crop like tuberose, where the cut flower form the main consumable product, a healthy and vigorous pre flowering period is an important contributing factor. Being a monocotyledonous crop, plant height in combination with leaf characters constitute the main vegetative parameters that influence spike characters.

Generally, the importance of plant height, lies in the fact that the number of leaves produced by the plant is related to stem length, since tuberose is a monocotyledonous crop. But tuberose is having its stem beneath the soil. So not much difference can be identified. However, the height of the plant is a net result

of the number of leaves produced and the length of the leaves in the plant. As such, plant height is influenced by the number of leaves produced and length of leaves.

A differential response was noted with bio regulators on plant height recorded at different intervals. Paclobutrazol at both concentrations (100 and 200 ppm) and BA at the lower concentration gave the lowest plant height. Variation was observed in the plant height given by paclobutrazol at 100 and 200 ppm. Application of CCC registered the lowest height increment in bulb dip 30 DAP, 60 DAP and at flowering. Treatment with paclobutrazol effectively dwarfed the plants. The reduction in height was so marked probably as a result of antigibberellic property of paclobutrazol, bringing disruptions and retardation in the stem elongation process. A significant height reduction of gladiolii plants consequent to paclobutrazol application was also reported by Barzilay *et al.* (1992). Paclobutrazol retarded plant height by inhibiting gibberellic acid biosynthesis (Rademacher, 1991).

Plant spread exhibited significant differences by the application of bio regulators. However, not much variation could be noted among the treatments. All the three bio regulators at any time of application were found to increase the spread of the plant. Bulb dip treatments did not show any increase in the N-S plant spread but the leaf area registered an increase.

Among the growth parameters, the number of leaves produced and the leaf area are most important, due to their influence on growth and yield of crop. One can estimate the degree of floral development by counting the number of

foliages visible. The differentiation influence from the apex occurs only after full number of leaves have been initiated. This may be due to the quantity of photosynthates that are accumulated by the plant which influences floral characters and spike production.

In the present investigation, the results indicate that more number of leaves were produced by paclobutrazol whereas BA bulb dip and control plants recorded the least number of leaves. This could be due to the activity of retardation in height so that more number of leaves can be produced. This increase in the number of leaves may also be due to inhibition of apical dominance (Marth *et al.*, 1995).

Present investigation makes it clear that, there is a significant variation in the length of leaf by application of bio regulators. Bulb dip treatments produced longer leaves when compared to all other treatments. Application of CCC and BA produced longer leaves. But in the case of leaf breadth, bulb dip treatments were similar to control. In general, bio regulator application resulted in broader leaves. In the first month not much increment was noted in the leaf area as there was no change in the breadth of the leaves. Total leaf area was found to be more for BA treatments as more number of leaves was produced by the application of BA.

Difference in the number of tillers was recorded only after 3rd month of planting. Maximum tillers were produced by CCC bulb dip in the 3rd, 4th & 5th months. Paclobutrazol recorded lowest tiller production which maybe due to its

antigibberellic activity. According to Parmar *et al.* (1993) number of sprouts per clump was increased by the application of GA.

Duration from planting to first spike emergence indicates early or delayed flowering in response to various treatments. From the experiment it was found that spike emergence was earlier with paclobutrazol and so also with CCC. But, BA treated plants took longer time for flowering than that of control. Delay in flowering by BA was reported by Reddy *et al.* (1997) in tuberose. Growth retardants like paclobutrazol and CCC tend to increase the endogenous gibberellic content in the plant resulting in early flowering than control (Shilo, 1970).

Differential response was observed with the treatments in the case of duration from spike emergence to opening. Treatment with BA resulted in delayed opening of florets while CCC registered early opening. Paclobutrazol showed best result only when applied at flowering.

Time to first floret opening was influenced by different treatments. The treatment with paclobutrazol 100 ppm applied at flowering recorded earlier floret opening while CCC in almost all the concentrations applied recorded earlier opening of florets.

In tuberose, after the first pair of floret opening, rest of florets open in succession. Opening starts from the lower most pair of florets. Thus one particular spike may last for one week up to one month, depending on the environmental conditions. This turn is determined by number of florets/spike and the life of individual floret. Among CCC, paclobutrazol and BA, paclobutrazol treated plants

completed floret opening first, followed by CCC. BA delayed opening thereby increasing the time taken for complete opening of florets in a spike. This might be due to the effect of BA in delaying senescence.

All the bio regulator treatments resulted in the production of longer spikes as compared to control. The long spikes are usually used for vase ornamentations to create a bold effect. Longer spikes were found to command premium prices in the market too.

BA treated plants gave longer spikes than paclobutrazol and CCC. Application of BA leading to longer spikes have been reported earlier by Reddy *et al.* (1997) and Gopinath (1997).

The strength of the spikes are decided by the girth of the spike. For paclobutrazol and CCC treatments, bio regulator applied at the flowering time gave maximum girth. But in the case of BA bulb dip treatment gave the maximum spike girth which may be due to the dwarfing effect of BA treated plants.

Depending on the number of florets per spike and spacing between the florets, the rachis length may vary. The arrangement of the florets on the spike may sometimes be such that, hardly any gap is left, thus enhancing beauty of the spike. In the present study, when the length of rachis as influenced by different treatments considered, response was not uniform. Maximum rachis length was registered with paclobutrazol 100 ppm and CCC 1000 ppm applied as bulb dip, since, more number of florets was produced by the above treatments.

Beauty of a tuberose spike is reflected by the number of florets it holds. Larger spikes, with more number of florets are ideal for cut flowers for indoor decoration. Tuberose spike with this character is of utmost importance. As to the response of bio regulators, all the treatments produced significantly more number of florets as compared to control. A decrease in the number of florets in BA treatments may arise from the effect of BA in increasing the number of side shoots due to which there is an increase in number of spikes produced but individual spike may be shorter and with less number of florets. Paclobutrazol and CCC treatments registered more number of florets per spike. Similar results have been reported earlier by Hassan and Agina (1980) and Choudhary (1987). Reddy *et al.* (1997) reported the positive influence of CCC in increasing the number of florets per spike.

Another important quality parameter of tuberose spike is the size of the florets, which in turn is determined by the length and breadth of the florets. Paclobutrazol 200 ppm applied at flowering gave the maximum floret length. But all other paclobutrazol treatments failed to increase the floret length than that of control. But BA at any concentration and at any time of application was found to increase the floret length. Floret breadth contributes to the boldness of the floret and hence is a very important character. Paclobutrazol applied at flowering time recorded the highest floret breadth. Increase in floret length by the application of BA was recorded by Parmar *et al.* (1993).

In the case of petiole length, flowers with long petiole were obtained from BA treated plants. But paclobutrazol gave the lowest petiole length, though, the floret length was more for paclobutrazol.

BA causes changes in osmotic potential by increasing the volume of mature cells. This may be one reason for increase in floret length, petiole length, leaf area and leaf length observed in BA treatments.

Longevity of individual floret also contributes to vase life of the whole spike. The results of the present experiment revealed that bio regulator treatment affected the floret longevity. BA when applied at 50 ppm gave the maximum longevity when compared to other treatments and control. Reduction in the longevity was noted by Manohar, 2000.

The longevity of spike in the field was found to be more with paclobutrazol applied at 60 DAP at a concentration of 100 ppm.

Yield is noted as the number of spikes produced per hill. In comparison to control, treatments with BA gave more number of spikes. This may be due to the fact that BA can redirect the assimilates which are essential for the production of blooms to the shoot apex.

The most important attribute for any cut flower is long vase life. Application of CCC 1000 ppm applied as bulb dip used was found to improve the vase life of tuberose spikes. According to Devendra *et al.* (1999) shelf life of tuberose cut flowers was greater with CCC.

Bulbs are the main storage structures in tuberose and healthy and larger bulbs will lead to vigorous plants producing quality spikes. Besides, tuberose bulbs are the main propagation material and hence assumes much economic importance.

Present studies clearly indicated the superiority of BA in improving the bulb characters. Bulb size showed only marginal improvement with BA treatment whereas CCC decreased the size of bulbs considerably. This might be due to its growth retardant property. Paclobutrazol also did not show any improvement in bulb size, which is in agreement with the results by Gopinath (1997).

During the process of growth, the new bulb produces a number of bulblets around it, which serves as a future propagule source. Though all the treatments could not show any significant improvement on size of bulblets over control, BA recorded a superior effect when compared to other two treatments.

In the case of number of bulbs, CCC produced more number of bulbs than that of control. This may be due to the fact that, size of bulbs produced by CCC is very less. The same result is observed in the case of number of bulblets also. More number of bulblets was produced by CCC treatment. Pappiah and Muthuswamy (1974) also observed similar results in dahlia.

Weight of bulbs was more in BA treated plants. Bulbs with maximum weight were observed with BA 50 ppm bulb dip and the least weight was for CCC treated plants because of the same reason that it produced, lighter bulbs. Application of BA at certain concentration and time of application produced

maximum weight of bulblets. But, the weight of bulblets was more critical with time of application.

Paclobutrazol treatments were found to be inferior with regard to all the characters pertaining to bulb production. This may be due to the fact that a marked reduction in the vegetative growth in turn leads to lesser assimilate production. This is reflected in the lower to medium bulb size.

Present investigations gave some positive indications, on the potential use of bio regulators as pre planting and post planting treatments in combinations with standard bulb grade in the commercial cultivation of tuberose. Further, comprehensive studies involving both the pre and post planting combination of bio regulators and their effect on the performance of a handful of varieties of tuberose are therefore in a way essential for arriving at some definite conclusions and useful recommendations in this regard.

Flowers harvested at the correct stage of maturity maintain better quality and vase life. If harvested at immature stage, they do not develop property in holding solutions and over matured flowers lasts only for a short duration. Generally, tuberose flowers are harvested when a pair or two pairs of lower most florets fully opened (Singh and Arora, 2000). According to paull *et al.* (1992) pre harvest and post harvest factors influence the longevity of cut flowers. He suggested that pre harvest factors explained 63.71 per cent of variation in post harvest life.

Pulsing is a short term treatment given in cut flowers immediately after harvest which improves the keeping quality of flowers. Its effect lasts even when the flowers are removed from the chemical and kept in water.

In the present study no improvement was noted in the fresh weight of the spike as a result of pulsing with any of the chemical viz. 8 HQS, sucrose and $AgNO_3$.

Pulsing with 8 HQS was found to complete flower opening earlier than that of other chemicals.

Number of florets opened at a time was not found to be increased or decreased by the pulsing solution. Spikes pulsed with silver nitrate absorbed more water whereas the least water uptake was by 8 HQS.

Vase life was more in spikes pulsed with $AgNO_3$ as more water uptake occured with this treatment.

Various holding solutions are used for the long term storage of cut flowers. The long term holding of cut flowers to extend their vase life was studied by Fischer (1952).

After flowers are cut and placed in water, they exhibit changes in fresh weight. Typically, cut flowers initially express increase and subsequently decrease in fresh weight (Roger, 1973). The fresh weight of the spike indicates its size. Pulsing with sucrose and thereafter keeping in sucrose solution was found to give maximum fresh weight of the spike because of the accumulation of carbohydrate in

cut spike. According to Naidu and Reid (1989) vase solution with sucrose improved display life of the stem. Alverz *et al.* (1994) also opined that the fresh weight of spike was greater in sucrose + 8 HQS.

The number of days required for the opening of each floret was significantly influenced by the different treatments. The number of days increased when both 8 HQS and $AgNO_3$ at higher concentration were used either as holding or as pulsing solutions. When sucrose was used, one floret opened each day. Sucrose fulfills the requirements for carbohydrate source and osmoticum which are necessary for floret growth and development (Kofranek and Halevy, 1976; Bhattacharjee, 1997).

The longevity of each floret also contributes to the vase life of the whole spike. Pulsing with sucrose and thereafter putting in 8 HQS solution took the least time for complete opening of florets, while maximum was observed for $AgNO_3$ pulsing and sucrose holding solution. Vascular blockage was inhibited by 8 HQS and sucrose which increased the moisture retention (Marousky, 1971). The endogenous ethylene can cause premature senescence and wilting of petals. Due to the anti microbial activity and anti ethylene activity $AgNO_3$ increased the days taken for complete opening of florets (Halevy and Mayak, 1981).

Another noteworthy character in an inflorescence which contributed towards the acceptability of a variety for commercial purpose is the number of florets opened at a time. The number of florets opened at a time was significantly influenced by the pulsing and holding solutions. More number of flowers were

opened with sucrose solutions than that of control. This might be due to the easy availability of carbohydrate to the flowers. Bhattacharjee (1997) also proved the efficiency of sucrose in flower opening.

The water balance of a cut flower is the result of water uptake and transpiration rate. After cutting, the transpiration rate of the flower remains nearly constant while the absorption rate declined continuously. Thus, in order to maintain a favourable water balance, there must be a good water uptake to equalize the water loss. Maximum water uptake was recorded with sucrose pulsing along with $AgNO_3$ holding solution and the least with 8 HQS pulsing and sucrose holding solution. Studies by Reddy *et al.* (1996) revealed that sucrose enhanced the vase life of tuberose flowers by increasing the water uptake and maintaining the water balance.

Vase life was more with $AgNO_3$ and sucrose. The beneficial effect of $AgNO_3$ may be due to the anti microbial (Halevy and Mayak, 1981) and anti ethylene activities of silver ions (Beyer, 1976). Paull (1987) revealed that $AgNO_3$ imparts resistance to chilling injury reduced the respiration rate of flowers and prevented microbial contamination of vascular tissues by acting as germicides. This inturn reduced the injury to flowers influencing their vase life positively. The benefit of sucrose is mainly because of the fact that sucrose replaces the depleted endogenous carbohydrate utilized during the post harvest life of flowers. Very low concentrations may not produce an optimal response where as excessive concentrations may cause harmful effect (Bhattacharjee, 1997).

After the spikes are placed in vase solutions and as the process of senescence proceeds, the electrolytes present in the cells of the tissues leach out. This leaching out of solutes into the vase solution is a result of increased permeability of cell walls. This leaching out was measured by measuring the electrical conductivity of the solution after the life of the spikes. Minimum leakage was recorded with 8 HQS where as maximum was with $AgNO_3$.

Year round production of flowers using, judicious and timely application of bio regulants has to be tried in future. Treatment with certain bio regulants like, CCC, resulted in the production of more number of small bulbs. Hence, the improvement in the propogation efficiency using bio regulants, can also be attempted.

SUMMARY

SUMMARY

Trials were conducted at the College of Horticulture, Vellanikkara, Thrissur during the year 1998-2000 to study the effect of bio regulators on the morphological and floral characters of tuberose. Studies were also conducted to standardize pulsing and holding solution in tuberose. Three bio regulators namely Paclobutrazol, CCC and BA each at two levels at different time of application ie., Bulb dip, 30 DAP, 60 DAP and at flowering were tried. The treatment was laid out in an RBD consisting of 25 treatments and 2 replications. The results of the investigation are summarised below.

The height reduction was found to be maximum with paclobutrazol treatment. At flowering, the height reduction was maximum for paclobutrazol 100 and 200 ppm 30 DAP. During the first month a minimum plant height of 13.75 cm was noticed with paclobutrazol at its lower level which is statistically on par with paclobutrazol 200 ppm (13.98 cm).

The plant spread exhibited significant differences by the application of bio regulator. Paclobutrazol bulb dip treatments had the lowest plant spread (15.50 cm and 11.87 cm) while CCC bulb dip treatment had the highest (24.25cm). In general, all the treatments resulted in lesser plant spread as compared to control (38.63 cm). Lowest increase in plant spread was noticed with paclobutrazol applied at 30 DAP (19.1 cm).

Paclobutrazol bulb dip treatments recorded maximum increase in plant spread (N-S).

Significant differences were obtained in the Number of leaves. Application of all bio regulators increased leaf number as compared to control. Among the treatments paclobutrazol was the best (55.86). Paclobutrazol applied at 30 DAP recorded lowest number of leaves.

The length of leaf was found to be highly influenced by the application of bio regulators. Application CCC 1000 ppm bulb dip had longest leaves (49.8 cm) BA 50 and 100 ppm also produced longer leaves. Bio regulators applied 30 DAP produced shorter leaves. Paclobutrazol 200 ppm produced the shortest leaves.

During the first month of planting, not much difference was noticed in the breadth of leaves. But seven months after planting, all the treatments produced broader leaves compared to control. Paclobutrazol 200 ppm 60 DAP had the broader leaves (1.93 cm).

With respect to leaf area, the bio regulator application influenced the character significantly. In the first month after planting, total leaf area was highest for BA 100 ppm applied 30 DAP (274.74 cm^2). In general, the bulb dip treatments did not exhibited any improvement in the leaf area over control. By the second month leaf area increase was more for CCC 1000 ppm 30 DAP. Control plants recorded minimum leaf area (1235.45 cm^2). Paclobutrazol 100 ppm bulb dip recorded maximum increase in leaf area than the initial month (3128.78 cm^2).

Tiller production was absent up to second month of planting. In the following months, maximum tillers were produced by plants receiving CCC 1000 ppm bulb dip (4.13, 4.38, 4.5). In the 6th and 7th months, plants treated BA 50 ppm applied 60 DAP produced maximum tillers.

Earliest spike emergence was recorded in plants treated with paclobutrazol 100 and 200 ppm applied 60 DAP (205.00, 204.00 days). BA treated plants took the longest time for spike emergence.

In the case of days to first floret opening paclobutrazol 200 ppm applied 60 DAP was the earliest (24.00 days). BA showed delayed floret opening.

Application of paclobutrazol at flowering, reduced the time taken for complete opening of florets when compared to control (20.82 days).

Significant influence of bio regulator on the spike length was evident from the experiment. Longer spikes were produced by BA treatments the best being 50 ppm bulb dip (97.37 cm).

Paclobutrazol 200 ppm applied at flowering produced maximum spike girth (2.81 cm). Bio regulator application showed significant variation between treatments and control except for paclobutrazol applied as bulb dip and 30 DAP.

Length of rachis showed significant variation among treatments. Paclobutrazol 200 ppm applied at flowering registered highest rachis length of 34.74 cm.

As regards the number of florets per spike, paclobutrazol applied as bulb dip was found to be superior (43.33) followed by paclobutrazol 100 ppm 30 DAP (42.00).

In the case of size of florets, significant variation could be detected among treatments. Length of the floret was highest for paclobutrazol 200 ppm applied at flowering (1.52 cm) and BA 50 ppm bulb dip. So also with flower breadth, highest was recorded with paclobutrazol 200 ppm applied at flowering (4.10 cm).

Maximum length of the petiole was observed in plants treated with BA 100 ppm applied at 60 DAP (2.35 cm) where on the least length was given by paclobutrazol 200 ppm bulb dip and 60 DAP (0.40 cm).

Longevity did not show much variation among treatment. Among the three growth chemicals maximum longevity was recorded in plants treated with BA 50 ppm bulb dip, 60 DAP and at flowering (2.50 days).

The best result in the case of longevity of spike in the field was given by paclobutrzol 100 ppm applied 60 DAP (42.5 days).

The treatments failed and influence the yield of spike per hill.

Vase life was found to be more with CCC 1000 ppm bulb dip (11.64 days). However, the lowest vase life was given by paclobutrazol 100 ppm 30 DAP (7.05 days) in the present study.

BA 50 ppm applied at flowering recorded the highest bulb size among the three bio regulators (15.1 cm).

Bulbs treated with CCC 500 ppm resulted in more number of small sized bulbs. Paclobutrazol application produced only lower number of bulbs.

Weight of bulb was found to be maximum in plants treated with BA 50 ppm 60 DAP, while CCC 500 ppm applied at 30 DAP resulted in lightest bulbs.

Maximum size of bulblets were observed in plants treated with paclobutrazol 100 ppm 30 DAP (7.24 cm) and the least by CCC 1000 ppm (2.60 cm).

Maximum weight of bulblets were observed in BA 50 ppm treated bulbs (128.75 g) least weight was given by BA 100 ppm bulb dip.

Maximum number of bulblets were produced in plants treated with CCC 500 ppm bulb dip (52.50) while the lowest was for BA 100 ppm bulb dip.

Standardization of pulsing solution in tuberose was studied with the treatments. None of the treatments significantly influenced the number of days for opening of each floret.

Treatment with 8 HQS 250 ppm (10 days), took maximum days for complete opening of florets, while, least number of days was taken by sucrose 10% (8.67 days).

No significant influence was noticed in the number of florets opened at a time with any of the bio regulator application.

Significant difference was noticed in the quantity of total water uptake by the influence various pulsing solution. Maximum uptake was noticed when pulsed with $AgNO_3$ 100 ppm (24.66 cm).

Vase life was found to be more with $AgNO_3$ 50 ppm pulsing (8.66 days) and minimum with sucrose 10 per cent (5.67 days).

Minimum electrolyte leakage was observed with $AgNO_3$ 100 ppm –0.04 in m Sg^{-1} and maximum with sucrose 15 per cent (0.10 m Sg^{-1}).

Standardization of holding solution was carried out with the treatments. Fresh weight of the spike was found to be maximum with sucrose 15 per cent and sucrose 4 per cent.

The number of days for opening of each floret was highest for 8 HQS 500 ppm and 8 HQS 400 ppm (3.00 days) and minimum with sucrose 10 per cent and 4 per cent (1 day).

Maximum days taken for complete opening of floret was for $AgNO_3$ 100 ppm and sucrose 2 per cent (17.33 days). Least number of days was registered for 8 HQS 200 ppm and sucrose 10 per cent (9 days).

Maximum number of flowers opened at a time (8.33) was recorded with sucrose 10 per cent and 8 HQS 400 ppm. Minimum number of florets opened at a time (1.33) was recorded for control.

Total water uptake was found to be significantly influenced by the application of various chemicals. Maximum uptake was recorded in spikes treated with sucrose 10 per cent and $AgNO_3$ 0.25 mM (50.2 ml), while water uptake was lowest 8 HQS 500 ppm and 8 HQS 400 ppm (5.36 ml).

Maximum vase life was given by spikes pulsed in $AgNO_3$ 50 ppm and put in holding solution containing $AgNO_3$ 0.25 mM (13.66 days). The vase life for tap water (control) was 6 days, while for distilled water, it was 6.6 days.

Minimum electrolyte leakage was recorded with 8 HQS 500 ppm and 8 HQS 400 ppm (0.002 m Sg^{-1}), while the maximum, was for spikes pulsed with 8 HQS 250 ppm and $AgNO_3$ 0.050 mM (0.10 m Sg^{-1}).

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APPENDICES

Appendix

Monthly weather data of the experiment site

Year	Month	Mean temperature (°C)		Mean Relative humidity (%)	Total Rainfall (mm)	Mean Sunshine (Hrs)	Mean wind speed (Km)
		Maximum	Minimum				
	August	29.8	23.3	86	433.6	3.6	2.5
	September	30.2	22.8	87	521.3	4.1	2.0
1998	October	28.0	23.1	85	452.8	4.8	2.1
	November	31.5	22.9	78	109.4	7.2	1.7
	December	30.1	21.5	69	33.0	6.6	5.7
	January	32.4	23.3	58	0.0	9.3	6.5
	February	34.5	25.6	56	22.8	9.1	5.1
	March	35.5	24.5	68	0.0	8.8	3.0
1999	April	33.4	24.7	73	39.0	10.3	3.3
	May	30.7	23.0	82	430.5	4.9	3.0
	June	29.4	23.0	85	500.2	5.0	2.5
	July	28.4	22.9	89	823.3	2.4	2.5
	August	29.8	23.4	84	260.1	5.5	2.3

REGULATION OF FLOWERING AND POST HARVEST BEHAVIOUR OF TUBEROSE (*Polianthes tuberosa* L.)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A study was undertaken at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during the year 1998-2000 to determine the effect of bio regulators on the growth and flowering of tuberose. Experiments were also conducted to standardize pulsing and holding solutions in tuberose.

The treatments, in general, significantly influenced all the morphological, floral and bulb characters.

The height reduction was found to be maximum with paclobutrazol 100 ppm applied at 60 DAP and 200 ppm applied 30 DAP. Highest plant spread was given by CCC bulb dip treatment. Paclobutrazol and BA bulb dip caused a significant increase in the number of leaves. Bulbs dipped in CCC 1000 ppm, BA 50 and 100 ppm produced longer leaves, when compared to control. Maximum tiller production was noticed in bulbs treated with CCC 1000 ppm. But, in later stages of growth, BA 50 ppm applied 60 days after planting gave more tillers.

Paclobutrazol applied 60 DAP, reduced the days required for the emergence of spike. Paclobutrazol 200 ppm applied 60 DAP recorded earlier floret opening, while, BA showed delayed opening.

Longer spikes were produced by BA treatments. The longest rachis was obtained with paclobutrazol 200 ppm applied at flowering. In the case of number of florets per spike, paclobutrazol applied as bulb dip was found to be the best.

Size of the floret was improved by the paclobutrazol applied at flowering. Petiole length was increased by BA 100 ppm applied at 60 DAP.

However, longevity of floret in the field was not affected significantly by the treatments. Best result in the case of longevity of spike in the field, was given by paclobutrazol 100 ppm applied 60 days after planting. Vase life of the spike was found to be more with CCC 1000 ppm bulb dip.

Bulb size was improved by BA 50 ppm applied at flowering. Bulbs treated with CCC 500 ppm, resulted in more number of small sized bulb and bulblets, while, the weight of bulb was found to be more with plants treated with BA 50 ppm 60 DAP. Bulblet size was more in plants treated with paclobutrazol 100 ppm 30 DAP and weight of bulblets was maximum with BA 50 ppm bulb dip treatment.

Treatment with 8 HQS 250 ppm, pulsing solution took maximum days for complete opening of florets. Total water uptake was found to be maximum in spikes, pulsed with $AgNO_3$ 100 ppm. Vase life was the maximum with $AgNO_3$ 50 ppm pulsing. Minimum Electrolyte leakage was noted with $AgNO_3$ 100 ppm.

Fresh weight of the spike was found to be maximum with pulsing solution sucrose 15 per cent and holding solution sucrose 4 per cent. Maximum number of days taken for each floret to open was recorded by 8 HQS 500 ppm and 400 ppm. Spikes in $AgNO_3$ 100 ppm and sucrose 2 per cent took maximum days for complete opening of florets. Number of florets opened at a time, was more with 8 HQS 400 ppm. Total water uptake was significantly influenced by pulsing with

sucrose 10 per cent and kept in holding solution $AgNO_3$ 0.25 mM. Vase life was more in spikes pulsed with $AgNO_3$ 50 ppm and put in holding solution $AgNO_3$ 0.25 mM. Minimum electrolyte leakage was recorded with 8 HQS 500 and 400 ppm.