EFFECT OF GROWTH REGULATORS ON GROWTH AND YIELD OF CALENDULA [*Calendula officinalis* (L.)]

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EFFECT OF GROWTH REGULATORS ON GROWTH AND YIELD OF CALENDULA [*Calendula officinalis* (L.)]

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Affectionately Dedicated to

My Beloved Parents

DIVISION OF HORTICULTURE

UNIVERSITY OF AGRICULTURAL SCIENCES

BANGALORE

C E R T I F I C A T E

This is to certify that the thesis entitled "EFFECT OF GROWTH REGULATORS ON GROWTH AND YIELD OF CALENDULA (*Calendula officinalis* (L.))" submitted for partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) IN HORTICULTURE to the University of Agricultural Sciences, Bangalore, is a record of bona fide research work carried out by Mr.T.RAJESH under my guidance and supervision and no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

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INTRODUCTION

I. INTRODUCTION

Calendula (*Calendula officinalis*, L.) popularly known as pot marigold, is one of the important cut flowers belonging to the family Asterceae. Calendula is a native of South Europe. Calendula are hardy and free blooming annuals with beautiful crowns, grown for garden decoration and for cut flowers. Calendula's are of diverse colours and used in making bouquets, garlands and for vase arrangement. It is used as bedding plant, for growing in pots, window boxes and other garden places where enhancement of colour in garden is required.

Calendula grows to a height of 30-45 cm with a green stem which are succulent, hispido-pubescent oblong leaves, some what succulent, margins entire, flower heads are terminal and solitary upon each branch. The heads contain many flowers each with single ovary, and the ovary is boat shaped. Florets at the centre are sterile and tubular. Colours vary widely ranging from deep orange, canary yellow, dark yellow, apricot and orange red.

Increased flower production, improved quality of flowers and perfection in the plant form are the important objectives to be reckoned in commercial flower production. Though the quality is primarily a varietal trait, but can be

influenced by the application of growth regulators. Large compact flowers with straight stalks are considered ideal for the cut flower industry, while for making garlands, the thickness of flower is of vital importance. Plants treated with growth retardants are generally compact and sturdy and have typically shortened internodes, dark green leaves and shortened petioles. Treated plants usually remain dwarf under optimal growing conditions. Systematic investigation to assess the effect of growth regulators on growth flowering, flower production in Calendula has not been made under field conditions.

Considering the importance of this crop, the present study was taken up with the following objectives :

1. To study the effect of mepiquat chloride and maleic hydrazide on growth and flower yield.

2. To determine the influence of varying concentrations of gibberellic acid on growth and flower yield.

3. To increase the longevity of cut flower with chemical preservatives.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Cultivation of Calendula (Calendula officinalis, L.) has received less attention and information available on use of growth regulators is very meagre. Hence such information in respect of other closely related flower and ornamental plants has been reviewed in this chapter.

The review of literature is presented under the following headings :-

2.1 Growth retardants and their effects
2.2 Growth promoters and their effects
2.3 Delay in flowering
2.4 Early Flowering
2.5 Retarding plant growth
2.6 Increasing plant size and yield
2.7 Apical dominance and growth retardants
2.8 Prolonging the vase life of cut flowers.

2.1 Growth retardants and their effects :

Growth retardants are chemical substances that slow down cell division and cell elongation in shoot tissues and regulates plant height without formative effects. Growth retardant treatment changes the morphology and physiology of plants. The anatomical changes may also influence increased

drought and heat tolerance. The growth retardants also provide protection from pollutants. Cathey and Heggestad (1973) reported that ancymidol and chlormequat provide protection to poinsettia from ozone and Sulphur-di-oxide. The ethylene diurea protected petunia plants exposed to ozone more effectively than daminozide (Cathey and Heggestad, 1982). Johnson et al., (1978) reported that ancymidol at 0.16 and 0.48 mg a.i/2.5 cm pot reduced sulphur-di-oxide damage in Chrysanthemum (Chrysanthemum morifolium Ramat cv Shastha.

Anatomical changes that provide protection against penetration by pollutants might also provide protection against insects and disease organisms. Halevy et al., (1970) found that ethephon dip for 30 minutes partially protected gladiolus corms from fusarium infection.

Tauber et al,(1971) reported that daminozide prevented an increase in the population of white fly (Trioleurodes vaparariumi) on petunia plants. Fisher and Shanks (1979) noted reduced whitefly populations on Chrysanthemum and poinsettia when plants were treated with 0.72 mg ancymidol or 1500 mg clormequat per 13cm pot. Brucke(and Wiggans (1969) reported that repeated applications of maleic hydrazide and Alar reduced effectively the low temperature injury in chrysanthemum

Growth retardants manifest their activities morphologically, anatomically and physiologically, so it is not surprising that growth may decrease the severity of some physiological disorders. The effect of growth retardants vary with plant species, variety, concentration of the retardant used, method of application and various other factors that influence the uptake and translocation of the chemical. Plants treated with growth retardants generally have thick and short stem with short internodes and thick and dark green leaves. Cathey (1964) reported a number of chemically diverse classes of compounds like nicotiniums, quarternary ammonium carbonates, hydrosine, phosphoniums substituted cholines, succinic acids and a number of other compounds tested and used as growth retardants.

2.2 Growth promoters and their effects :

Plant growth promoting substances promote cell elongation and cell enlargement. The physiology and morphology of plants are changed by these substances. Dahab et al., (1987) reported that gibberellic acid increased the fresh weight, dry weight, Chlorophyll and Carotenoid contents but decreased fresh weight of inflorescence in Chrysanthemum frutescens. Exogenous GA_3 spray 15 days after planting increased root numbers and the activity of growth

promoting substances in the basal part of cuttings of chrysanthemum (. . . . .). Gibberllin applications does not influence the low temperature injury in chrysanthemum (Bruckel and Wiggans, 1969).

2.3 Delay in flowering :

Jauhari and Amarjit (1960) reported that a drench spray of maleic hydrazide at 500 ppm increased the average number of lateral shoots and flowers per plant while plant height was reduced with delayed flowering. Higher concentration of 1000 to 2000 ppm markedly reduced height, number of laterals and delayed blooming in china aster. Powell and Anderson (1957) recorded the effects of maleic hydrazide at 1200 ppm completely stopped terminal growth. Maleic hydrazide induced stimulation of laterals, retarded growth of lateral and promoted production of large number of abnormal flowers delay in flowering and reduction in yield due to maleic hydrazide application has been reported in flowering annuals (Sen and Sen, 1968) and in chrysanthemum (Sen and Maharana, 1972).

Armitage et al.,(1987) showed that Daminozide did not induce differences in flowering time in Calendula officinalis cv. Mandarin, when applied at (0,1500, 3500, or 5000 ppm) 3, 4, 5, 6 or 7 weeks from sowing or once at 5

weeks and once at visible bud stage. Maleic hydrazide spray delayed the flowering time in china aster cv. Powder puff mix, maximum number of days taken for flower bud appearence (120.43 days) was with 1500 ppm MH as against control of 108.33 days (Aswath, 1991).

Narayana Gowda (1990) reported the delay in flowering owing to cycocel spray in china aster, Adriansen (1985) reported that application of growth retardants (ancymidol, piproctanyl bromide and Daminozide) resulted in delayed flowering by few days in chrysanthemum. Application of paclobutrazol delayed flowering in chrysanthemum cv. Bright Golden Anne. The paclobutrazol exhibited delay in flowering to ancymidol and daminozide and piproctanyl bromide were 2-4 days greater (Menhenett, 1984). Delay in 50 per cent flowering by application of maleic hydrazide was noted by Nagarjuna et al., (1988) in chrysanthemum. Further reported that the spraying of maleic hydrazide was more effective than dipping.

Narayana Gowda and Jayanthi (1992) observed delay in flowering of African Marigold owing to cycoel and Maleichydrazide sprays. McConnell and Struckmeyer (1970) studied the response of marigold to daminozide and two different day length treatments. They observed darker

coloured foliage two days after plants were treated with the growth retardant with shorter internodes and delayed flowering.

Armitage et al., (1981) found that three to four applications of ancymidol and or daminozide to Zinnia seedlings delayed flowering and reduced fresh weight. Srivastava and Bajpai (1964) reported 100 ppm of maleic hydrazide spray delayed flowering in Calendula (Calendula offi cinalis).

Flowering was delayed by as much as one week with some ancymidol treatments, particularly at highest concentrations, but only one to two day delay in flowering was caused by daminozide treatment of potted chrysanthemum (Larson and Kimmins, 1972). Shanmugam and Muthuswamy (1974) revealed that spray of CCC and TIBA each at 5000, 10,000 and 15000 ppm on chrysanthemum yellow delayed flowering.

The flowering in case of china aster was delayed by 14 days at 1000 ppm maleic hydrazide spray as compared to control (Narayana Reddy, 1978). Delayed flowering of china aster due to application of 1000 ppm cycocel and pinching (Narayana Gowda, 1985). Maleic hydrazide at 1000 or 2000 ppm delayed flowering in chrysanthemum (Shanmugam and Muthuswamy, 1974).

Maleic hydrazide and CCC delayed flowering in chrysanthemum at 50 and 75 ppm.(Dutta. et al., 1993), Nagarjuna et al., (1988) reported that 250 and 500 ppm MH delayed flowering in chrysanthemum.

2.14 Earliness in flowering :

Dahab et al., (1987) reported in Chrysanthemum florescens that Gibberellic acid at 500 and 1000 ppm accelerated days to flowering. Nagarjuna et al,, (1988) observed that when Gibberellic acid at 100 and 200ppm sprayed on chrysanthemum (Chrysanthemum indicum L.) hastened 50 per cent flowering. Dutta et al,, (1993) reported that when Gibberellic acid was sprayed at concentration of 50 and 75 ppm on chrysanthemum (Chrysanthemum indicum. L) hastened the flowering.

Gibberellic acid at 500 ppm on marigold (Tagetes erecta. L.) hastened days to flowering (Singh et al, 1991). Narayana Gowda and Jayanthi (1992) observed delayed flowering in African marigold owing to cycocel and maleic hydrazide sprays. Shanmugam et al., (1975) reported that in chrysanthemum (Chrysanthemum indicum L.) Gibberellic acid induced earlier flowering at 100· ppm.

Shanmugam and Muthuswamy (1974) reported that CCC and TIBA each at 5,000, 10,000 and 15,000ppm induced earlier

flowering in chrysanthemum cv. white.

Reddy and Sulladmath (1972) reported that in china aster gibberellic acid at 100, 200, 300 ppm resulted in earlier flowering. When gibberellic acid at 100 and 200ppm sprayed on chrysanthemum hastened 50 per cent flowering. Dutta et al,,(1993) reported that when gibberellic acid was sprayed at 50 and 75 ppm on chrysanthemum hastened the flowering.

Gibberellic acid at 500 ppm on marigold (Tagetes erecta L) hastened the days to flowering (Singh et al., 1991). Narayana Gowda and Jayanthi (1992) observed delayed flowering in African marigold owing to cycocel and maleic hydrazide spray. Shanmugam et al,,(1973) reported earlier flowering at 100-400 ppm in Chrysanthemum.

Shanmugam and Muthuswamy (1974) reported that CCC and TIBA each at 5000, 10,000 and 15000 ppm induced earlier flowering in chrysanthemum cv. white.

Reddy and Sulladmath (1972) observed earlier flowering with gibberllic acid at 100, 200 and 300 ppm resulted in china aster.

2.5 Retarding plant growth

Growth reduction due to cycocel has been observed in

chrysanthemum (Lemper, 1964) and in Dahlia (Bose, 1965). Maleic hydrazide alone reduced the plant height, but in combination with GA there was no reduction in Zinnia (Saha, 1966). Narayana Reddy (1978) reported in china aster that application of maleic hydrazide at 750 and 1000 ppm resulted in significant reduction in internodal length and increased number of branches with no influence on flowering. Further he noticed that maleic hydrazide at all concentrations reduced peduncle length, flower diameter, thickness of flowers and number of flowers. Narayana Gowda (1992) reported retardation in plant height with internodal reduction owing to cycocel in china aster.

Sen and Naik (1977) observed the maximum reduction in growth of chrysanthemum with 200 ppm maleic hydrazide and cycocel at 1000 ppm. Cycocel at 0.25, 0.50 and 1.0 per cent and maleic hydrazide at 250, 500 and 1000 ppm decreased the final height of cultivar early white (Sen and Maharana, 1972) Chrysanthemum plants treated with chlormequat were 6-16 cms shorter than untreated plants, their leaves were darker, larger and thicker and they were less likely to wilt under water stress (Lindstorm and Tolbert, 1960).

Sachs and Kofranek (1963) demonstrated that retardants reduced the number of cell divisions in the apical meristem

of chrysanthemum plants and there by caused shorter stems.

McConnel and Struckmeyer (1970) noticed in marigold that alar spray at 500 and 1000 resulted significantly shorter plants than the controls because of shorter internodes.

Application of Daminozide at 3500 ppm twice once at sowing and again at visible bud stage resulted in excellent height control of Calendula officinalis cv. mandarin by reducing both peduncle and internodal length (Armitage et al., 1987).

B-nine sprays applied to pot chrysanthemum reduced plant height and flower weight (Buxton and Culbert, 1967) B-nine when sprayed at 5000 and 10000 ppm significantly reduced the plant height (Bhattacharjee et al, 1974).

Reddy and Sulladmath (1972) noticed in china aster (Callistephus chinensis) that maleic hydrazide at 500, 750 or 1000 ppm reduced the peduncle length, flower diameter and flower thickness. Narayana Gowda (1992) reported that reduction in flower peduncle length, when sprayed at nursery stage with cycocel. Maleic hydrazide at 50 ppm spray reduced plant height significantly in calendula (Srivastava and Bajpai, 1964). Powell and Andreasen (1956) found in chrysanthemum

that cessation of terminal growth was with 1200 ppm spray and 900 ppm drench with maleic hydrazide. Stem length was reduced at 1000, 2,000 or 4000 mg/lit of daminozide on chrysanthemum (Hicklenton, 1990).

Bhattacharjee (1974) reported that TIBA at 2000 ppm or maleic hydrazide at 500 ppm markedly reduced the plant height in Dalhia cv. Kelvin Rose. Maleic hydrazide at 150 ppm was effective and retarded the plant height in both aster and marigold (Lal and Mishra, 1986).

Daminozide was most effective in producing optimum size petunia plants (80mm height) at 1250, 2500 or 5000 mg per litre. However at higher concentration and more number of applications reduced plant height below optimum of 80mm and further noticed that paclobutrozol was least effective chemical (Poll et al., 1990).

Aswath (1991) observed the reduction in plant height owing to foliar sprays of maleic hydrazide, cycocel and Alar at 1500 ppm in china aster cv. powder puff mix, Narayana Gowda (1992) reported in chinaaster the reduction in plant height due to pinching and cycocel spray both at nursery and after transplanting in the main field.

2.6 Increasing plant size and yield

Plants of 'Sovereign' and F_1 cultivars of Tagetes erecta growing under both short and long days were given

weekly foliar sprays of SADH of 500, 1000 or 2000 ppm where short day control plants were shorter, flowered earlier and had shorter leaves than long day plants. SADH delayed flowering of treated plants upto eight days in each photoperiod compared with the respective control. However, the terminal flowers of the short day plants were of the same size as those of control. SADH sprays also resulted in shorter plants. denser foliage and wider leaflets (McConnell and Strucmeyer, 1970).

Srivastava and Bajpai (1964) observed that maleic hydrazide sprays reduced the mean height of main shoot, increased the number of days taken for first flower and increased the number of flowers per plant upto 50 ppm in calendula.

Novosalova et al.,(1985) reported that application of cycocel at 2-5 per cent as drench increased inflorescences and intensity of greeness in leaves of marigold.

Gibberellic acid as a foliar spray of 200 ppm on marigold and china aster increased the number of flowers per plant (Syamal et al., 1990).

Singh et al.,(1991) noted that 500 ppm of GA_3 increased growth, flower yield, number of flowers per plant, flower weight and duration of flowering in African marigold (Tagetes erecta L.)

Highest number of laterals were observed in china aster plants with drench spray (one month after transplanting) of 500 ppm of maleic hydrazide (Jauhari and Amarjit, 1960).

Gibberellic acid at 100, 200 or 300 ppm increased the peduncle length of china aster flowers (Reddy and Sulladmath, 1972).

Narayana Gowda (1985 and 1990) reported that the increased number of branches, nodes and leaf area due to the application of cycocel (ccc) 1000 ppm in china aster cv. Ostrich plume.

Narayana Gowda (1992) reported increased number of laterals and flowers per plant owing to pinching and cycocel sprays in china aster However, Aswath (1991) reported in chinaaster cv. Powder puff mix a spray of 1500 ppm cycocel on 25th, 40th, and 55th day after sowing increased the number of branches (24.43) and resulted in maximum number of flowers per plant (65.23)

When bench grown chrysanthemums were sprayed or drenched with maleic hydrazide of 900, 1200, 1800 and 3000 ppm significantly produced more laterals in all the treatments (Powell and Anderson, 1956).

Sen and Maharana (1972) observed in chrysanthemum that

gibherellic acid spray caused hyper elongation of stem and internodes and also increased leaf area and petiole length.

Nagarjuna et al., (1986) observed that a spray of 100, 200 ppm of gibberelic acid on chrysanthemum resulted in increased plant height, number of laterals, number of suckers per plant, flower size and weight of flowers.

Gibberellic acid at 500 and 1000 ppm increased plant height, diameter of stem, number of shoots per plant and length of shoots in Chrysanthemum frutescens. (Dahab et al., 1987).

Higher flower diameter (5.92-5.99cms) was recorded with the spray of 200 ppm of gibberellic acid in chrysanthemum (Nagarjuna et al., 1988).

Holcomb et al.,(1991) observed in chrysanthemum that folar spray of 20mg GA_3 /lit increased the plant height and peduncle length.

Dutta et al., (1993) reported that Gibberellic acid at 150 ppm on 45 day old chrysanthemum plants resulted in higher yields of 0.682 Kgs per plant as against control (0.253 Kgs per plant).

2.8 Apical dominance and growth retardants

Apical dominance is encountered in the production of

most floricultural crops, the removal of shoot apices to overcome apical dominance and to promote lateral shoot development is referred to as pinching. Pinched cut flower crops usually are more productive than single stem plants. Pinching of chrysanthemums, carnations, china aster and marigold is not a major task, each plant has only one major axis and removal of shoot apices can be done rather quickly. Pinching requires more labour. In some instances, chemical pinching has improved lateral branching, justifying its use, even though man ual pinching was not necessarily laborious.

Beach and Leopold (1953) reported that a spray of 100 ppm maleic hydrazide resulted in as good or better pot plant than pinch treated plants in three varieties of chrysanthemum. The varietal responses to the various treatments were similar and the flower quality and salability of sprayed plants were in no way inferior to the pinched ones.

Menhenett (1978) used 2,3 dihydro - 5,6 - diphenyl 1-1, 4 - oxathin at 0.4-0.8 per cent active ingradient to chemically pinch chrysanthemums. The chemical was applied to shoot apices a few days after planting. Its effectiveness as a pruning agent was influenced by time of application as it is for disbudding.

Dikegulac was developed in mid 70's (Anonymous, 1976) and immediately showed potential for pinching several ornamental plant species. It has successfuly promoted lateral branching of herbaceous plants such as Begonia, Calceolaria, Kalanchoe and Peperomia.

In Salvia and Verbena a spray of 0.05-0.16 per cent dikegulac reported to be adequate for herbaceous plants, further reported that more woody species such as bougainvillea, fuchsia, clerodendron and ficus require higher concentrations of 0.1 - 0.3 per cent (Anonymous 1979a).

Carpenter et al., (1971) when applied PBA(200 and 300 ppm) and BA (500 and 1000ppm) to poinsettia cultivars noted an increase in lateral branching. Shanks and Purohit (1978) tried numerous chemicals to promote lateral branching of poinsettia and found that 3000 ppm, dikegulac was most effective on cv. Eckespoint c-1 Red plants.

Cathey (1970) discussed the plant characteristics that help to determine the effectiveness of chemical pinching agents. Plants in a vegetative state with elongated stems and with foliage that readily absorbs and responds quite readily to chemical pinching agents, on the other hand, plants in the reproductive state with waxy foliage and in

which growth occurs in flushes do not respond well. Environmental factors can also affect the response. For example, chemicals may be more effective at 30 °C than at 13-29 °C because penetration is delayed at temperatures less than 13 °C and greater amount of pinching agents might be required to produce the same effects obtained at higher temperatures.

2.8 Prolonging the vase life of cut flower

Culbert (1965) reported that a single application of 0.5 per cent B-nine to potted chrysanthemum plants 2-3 weeks after subjecting the plants to short days, shortened the internodes most effectively and prolonged the life of the flowers as compared with untreated control. Buxton and Culbert (1967) demonstrated that spraying chrysanthemum cv. yellow delaware with SADH increased flower life upto five days. The longest flower life resulted from an application of SADH at 2500 ppm applied three weeks after commencement of shortdays.

Shawareb (1987) reported that application of alar increased chlorophyll content of leaves and shelf life of flowers of chrysanthemum.

Shawareb and Qrunfleh (1988) observed delayed flowering from 2-4 days and increased shelf life of the pot

chrysanthemum plants due to application of 1250 ppm alar as spray. Dutta et al., (1993) reported that application of 150 ppm gibberellic acid on chrysanthemum resulted in longest cut flower shelf life of 20.0 days as against 8.67 days in control.

2.9 Effect of sucrose

Sugars play an important role in flower development and opening either as energy source for respiration or as osmotically active substances which aid in maintaining the turgidity of the expanding corolla. Sugars also have beneficial effect on maintaining higher fresh weights in cut flower shoots by inducing stomatal closure in the leaves and thus reducing water loss. The optimum concentration of sugar varies with the treatment and the flower. Generally for a given flower the longer the exposure to the chemical solution the lower the concentration required and vice-versa.

Flower senescence during vaselife is correlated with a reduction in sugar content of the flower (Bruszewki, 1970; Nowak, 1979; Ferreira and Swardt, 1980) which resulted in wilting (Belynskaja, 1964; Gambkoto et al., 1968; Nichols, 1973, Lukaszewska, 1980). Supplying cut flowers with exogenous sugar maintains the respirable substrates in the

flower (Nichols, 1973, 1975, Lukazewska, 1986) promotes respiration (Wilkins, 1965 and Coorts, 1973) encourages protein synthesis (Paulin, 1986) and delays the onset of excessive protein degradation (Paulin, 1971, Coorts, 1973, Parups and Chan, 1973) and thus extends the longevity of cut flowers (Coorts, 1973 and Rogers, 1973).

Sucrose improves water balance in cut flowers (Aarts, 1957 ; Bravdo et al., 1974, Halevy and Mayak, 1974 and Borochov et al., 1976. Acock and Nichols, 1979 and Narayana Gowda, 1990). This was attributed to the effect of sugars on the closure of stomata and reduction of water loss thereby increasing the fresh weight of the flower (Marousky, 1971 and Narayana Gowda, 1990). The translocated sugars accumulate in the flowers increasing their ability to absorb water and maintain turgidity (Halevy and Mayak, 1979 and Halevy, 1976). The improvement of water balance was also associated with reduced endogenous level of ABA (Borochov et al., 1976) which is a typical response to reduction of water stress, reduced (Wilkins, 1965) or delayed (Dilley and Carpenter, 1976) production of ethylene.

Sucrose enhanced the effect of cytokinin in delaying senescence of flowers and reduced the effect of ethylene in promoting it thereby increasing the vaselife of the flowers, (Mayak and Dilley, 1976).

The supplied sugar may also reduce naturally occuring starch hydrolysis and lipid degradation in roses (Molhar and Parups, 1977), it prevented an undesirable accumulation of free amino acids in the flowers (Lukaszewska, 1986) which is a symptom of flower ageing (Ferreira and Swardt, 1980, and Lukaszewska, 1980). The main effect of applied sugar in extending longevity is to maintain mitochondrial structure and functions (Kaltater and steponkus, 1976).

Sucrose in the vase solution has been found to increase the vase life of gladiolus (Anserwadekar and Patil, 1986, Bravdo et al., 1974, Choi and Roh, 1980, Narayana Gowda and Nage Gowda, 1990, Lukaszewska, 1981) daffodils (Piskornik and Piskornik, 1980) tuberose (Balakrishna, 1987 and Narayana Gowda, 1986) confirmed that sugar improves the water balance and osmotic potential of flowers. Mantur and Nalawadi, (1989) reported that in chinaaster a maximum vase life of 8.0 days and 8.3 days in Kharif and Rabi respectively at 2.0% sucrose against control 5.0 days and 7.4 days in Kharif and Rabi respectively.

In china aster cut flowers, longest vase life at 133.17 to 14.63 days was observed with 0.4% Aluminium sulphate + 2% sucrose (Narayana Gowda, 1986). Pulsing of cut chrysanthemums in 50mg/l silver nitrate + 200mg/l HQS + 5% sucrose for 20 hours had longest vase life of 7.5 days

(Ketsa, 1989). Pulsing of cut gerbera inflorescences in silvernitrate (200 mg/l) or 8-HQC (200 mg/l with sucrose (100mg/l) for 24 hours at 20 ^{o}C reduced the number of bent or folded stalks (Nowak, 1989). Placing of calendula and zinnia cut flowers in 10 per cent sucrose after silver nitrate dipping enhanced their longevity (Awad et al., 1989).

Accati and Jona (1989) reported that mixture of 300 ppm 8 - HQS, 300 ppm sodium benzoate, 10^{-4} m aminoxy acetic acid, 10^{-4} m 3,4,5-T and 20g/l sucrose is best vase solution to increase longevity of cut gerberas. Saradhi and Ram (1989) reported that longer vase life of cut chrysanthemums was obtained with cobalt chloride (12-14 days) 7 days in sucrose and 3-4 days in IAA and cobalt chloride + sucrose (22-24 days).

2.11 Effect of metallic salts

Shobha (1992) working on post harvest life of calendula observed that increased vaselife with $Cu(so_4)_2$ at 0.75 m and silver thio sulphate at 0.5 mg and $Al_2(so_4)_3$ at 1 m for 2-3 days as compared to control.

Shobha (1992) observed increased vase life of cut calendula flowers by $Cu(so_4)_2$ by 3 days. Extended post

harvest life was recorded at 0.75 m $Cu(so_4)_2$ (7.33 days) are compared to control 4.33 days. The increased vase life was with increased concentrations of various metallic salts tried in the study.

2.12 Water relations

The termination of vase life of many cut flowers is characterized by wilting and therefore many studies have been made at evaluation of events leading to this phenomena (Halevy and Mayak, 1981). A high level turgidity is necessary for development of flower buds to full bloom maturity, it is also necessary for the continuance of normal metabolic activity in the cut flower, turgidity in plants and flowers is dependent upon a balance between the rate of water loss or utilization and water supply (Rogers. 1973).

Simultaneous measurement of water uptake and water loss were determined in some cut flowers (De stigter, 1980 and Mayak et al., 1974). These two parameters certainly influence each other and their interactions determine the water balance (Halevy and Mayak, 1981) which inturn influences flower turgidity (Rogers, 1973). In cut flowers loss of water from all tissues depends on environmental and internal factors. In roses and other cut flower water loss

decreased sharply due to stomatal closure (Mayak et al., 1974), water loss then paralleled water uptake (Halevy and Mayak,1974) and finally an increase in water loss occured before wilting (Halevy and Mayak,1974).

Water uptake and water loss may fluctuate cyclically with an over all declining trend (Carpenter and Rasmussen, 1973, Mayak et al., 1974 and De stigter, 1980). However the balance of two processes affect the fresh weight change (Halevy and Mayak, 1981). Typically cut flowers initially increase and subsequently reduce in fresh weight (Rogers, 1973 and Narayana Gowda, 1990). Decreased rate of water uptake led to the loss of petal turgidity and fresh weight (Durkin and Kuc, 1966) which ultimately reduced the flower vaselife (Faragher et al., 1986). Increase in fresh weight can occur only when the rate of water absorption is greater than the transpiration rate (Rogers, 1973). Water uptake and flower abscissions are the major physiological factors which limit vase life (Faragher, 1986). Stem plugging and reduced water transport capacity have been related to the presence of micro-organisms in holding solutions (Ford et al., 1961) which can result directly from the physical plugging action of masses of microbial cells clustered around the base of the flower stem or indirectly from the accumulation of plugging substances released into the water

by microbial contaminants (Aarts, 1957).

The reduction in water uptake coupled with continuous transpiration leads to water deficit and reduced turgidity in the cut flower (Halevy and mayak, 1981). Water deficit - water potential relations of the petals change with age resulting in a lower water holding capacity (Van meeteren, 1978, 1979. Acock and Nichols. 1979). A decline in water conductivity seems to be a general phenomenon in many ageing cut flowers (Halevy and mayak, 1981). The redution in stem conductivity is apparently caused by several factors. The major factor contributing for the rapid deterioration of cut flowers is vascular blockage, which begins at the cut end and moves upward in the stem with time (Chandrashekaraiah, 1973 and Sacalis, 1975).

In treatments where microbial growth was greatest (as observed under microscope) water flow through the stems was least in carnation (Laurie, 1936). Germicides controlled microbial growth and partially reduced the resistance to water flow when used as vase solution for tuberose (Narayana Gowda, 1990) thereby helping the flower stems to maintain a higher rate of water transport and enhanced vase life (Laurie, 1936).

Bacterial plugging appears to be a much greater

practical problem in naturally long lived flowers life of tuberose and gladiolus than in short lived ones like roses, since there is more time for large population of microorganisms to buildup in the former (Rogers, 1973). Therefore micro-organisms were considered to be one of the main causes of reduced water uptake by cut flowers (Halevy and Mayak, 1977).

Cut flowers kept in solutions containing only bactericidal chemicals often keep no longer than those in plain water (Wiggins and Pyne, 1963).

In addition to microbial induced stem plugging, there are instances of physiological stem plugging that ocur even under aseptic conditions (Rogers, 1973). Vascular blockage is of oxidative nature resulting either from substances secreted by damaged cells (Aarts, 1957) or harvesting injury (Durkin and Kuc 1966).

Cut chrysanthemums placed in water at 20 ^{0}C their water balance became negative from the first day of vaselife. This was due to disturbed water uptake due to air coming into the vessels of the stem after cutting. Water loss of the flowers had no influence on the water balance during vaselife. (Meeteran, 1989).

MATERIAL AND METHODS

III MATERIAL AND METHODS

The field trial was conducted at the floriculture unit of the Division of Horticultural Sciences, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore-560065 during 1993-94.

3.1 Geographical location of the experimental site

Horticultural Research station is situated at 12° 58' North latitude and 77° 35' East longitude with an elevation of about 930 meters above the mean sea level.

3.2 Soil and its character

In the experimental site the soil was red sandy loam with P^H range of 5.5 to 6.0. The available nitrogen content and phosphorus content were 94 kg /ha and 18 kg /ha respectively and exchangeable potassium content was 132 kg/ha. (Appendix-I and II).

3.3 Plant Material

Calendula cv. Orange King used for the study is an annual herb with succulent stem, sessile leaves with alternate phyllotaxy, erect growing and branching, bracteate with inflorescence being the captilum.

Experimental Details

3.1 Experiment - I

Effect of Maleic hydrazide, Mepiquat chloride and Gibberellic acid on growth and flowering of Calendula.

Crop : Calendula (Calendula officinalis L) cv. Orange King

Design : Randomised complete block design.

Treatments : 15

Replications 3

Gross plot : 1m x 1m

spacing : 30 x 20 cms

Treatments :

T_0 - Control

T_1 - Maleic hydrazide 50 ppm

T_2 - Maleic hydrazide 100 ppm

T_3 - Maleic hydrazide 250 ppm

T_4 - Maleic hydrazide 500 ppm

T_5 - Mepiquat chloride 50 ppm

T_6 - Mepiquat chloride 100 ppm

T_7 - Mepiquat chloride 250 ppm

T_8 - Mepiquat chloride 500 ppm

T_9 - Gibberellic acid 50 ppm

T_{10} - Gibberellic acid 100 ppm

T_{11} - Gibberellic acid 200 ppm

T_{12}	-	Gibberellic acid 300 ppm
T_{13}	-	Gibberellic acid 400 ppm
T_{14}	-	Gibberellic acid 500 ppm

The freshy prepared growth regulators were sprayed on the plants as outlined in the treatment details on 50 and 65 days after sowing.

3.3.2 Nursery operations

Good quality seeds were sown in the seed pans containing mixture of sand and FYM (1:1) and as a prophylactic measure the seed pans were drenched with 0.1 percent captan.

Seed germination was observed within 5-6 days and were protected from insect pests and diseases in nursery stage.

3.3.3 Preparation of experimental plot

The plot where the experiment was proposed to be conducted was brought to fine tilth after ploughing., digging and levelling. The experimental plot was divided into plots of size 1m x 1m with 30 cm bunds between the plots. Irrigation channels of size 0.5 m were provided in between two rows. To each plot 10 kgs of well decomposed farm yard manure was incorporated before transplanting the seedlings.

3.3.4 Transplanting

30 days old seedlings were transplanted with a spacing of 30 x 20 cm and irrigated lightly immediately after transplanting.

3.3.5 Application of fertilizers

NPK at the rate of 180:120: 60 kgs per hectare applied in the form of urea , Single super phosphate and murate of potash respectively. The entire quantity of phosphorous and potassium and 50 percent of nitrogen were applied as a basal dose, the remaining 50 per cent nitrogen was applied as top dressing 30 days after transplanting.

3.3.6 Irrigation

Irrigations were given once in a week depending on the soil moisture conditions.

3.3.7 Plant protection and weed control

The crop was sprayed with 0.2 per cent dimethoate as a prophylactic measure against leaf eating caterpillar and head borer. Hand weeding and cleaning of channels was regularly done to keep the plots weed free.

3.3.8 Collection of experimental data

Five plants were selected at random and tagged in each

treatment plot for recording the growth parameters.

3.3.9 Growth parameters

Plant height was measured from the ground level to the growing tip of the plant. This observation was recorded at 60, 75, 90, 105 and 120 days after sowing. The total number of leaves produced in each plant was counted in the same five labelled plants at 60, 75, 90, 105 and 120 days after sowing. The number of branches arising from the main stem were counted in five plants and the average value was recorded as number of branches per plant. This observation was recorded at 60, 75, 90, 105 and 120 days after soeing. The total number of nodes on the main stem were counted and recorded as number of nodes per plant. Average internodal lengths were obtained by random selection of nodes and internodes for measurement. Total leaf area of all leaves in a plant was measured using licer leaf area meter after defoliation at the time of flowering.

3.3.10 Flowering parameters

i) Number of days taken for flower bud appearance

This observation was recorded by counting the days from the date of sowing till intiation of flower bud in each treatment plot. The first five flower buds that were

intiated in each plant were tagged. The average of these five termed the mean number of days taken to bud initiation for each plant.

ii) Flower longevity on the plants

Average number of days from the date of anthesis to the date of flower withering formed the mean longevity of the flower on the plant.

iv) Total flowering period

Average number of days from the flower bud opening to the last flower withering in the particular plant.

v) Number of flowers per plant

From the same randomly selected plants number of flowers per plant was counted and recorded as number of flowers per plant.

vi) Flower diameter

From each plant five fully opened flowers were randomly selected and their diameter was measured.

vii) Number of days for 50 per cent flowering

The number of days for 50 per cent flowering was

recorded after a continous visual observation of the plots and regular flower counts were taken. Then finally the number of days with 50 per cent of the flowers possessed was recorded.

viii) Yield of flowers per plant

As and when the harvesting was done the fresh weight of the flowers from the five plants were recorded. Then the yield of flowers per plant was obtained by dividing total weight of flowers from the number of plants.

ix) Peduncle length

The distance between the basal end of the pedicel and the bottom end of the flower was noted. The peduncle length was measured in five flowers selected and average value was calculated.

x) Dry weight of the flowers per plant

The earlier harvested flowers for yield purpose were used and dried in oven at 70 ^{o}c till a constant weight was obtained.

xi) Dry weight of the plant

The five plants were harvested and dried in an oven at

70 °c till a constant weight was obtained. The average value of five plants was noted as dry weight of the plant.

xii) Method of statistical analysis

Fischer's (1963) method of analysis of variance was adopted for the analysis and interpretation of the data. 'F' and 'T' tests were conducted and the results were tabulated.

EXPERIMENT - IA :

Effect of growth regulators and Sucrose on postharvest life of cut flowers of Calendula.

Design : Randomised Complete Block Design

Treatment : 15

Replications 3

Treatment Details :

Maleic hydrazide 50, 100, 250, 500 ppm

Mepiquat chloride 50, 100, 250, 500 ppm

Gibberellic acid 50, 100, 200, 300, 400, 500 ppm

Flowers were harvested when they were fully opened. The stems were cut to a uniform length, removal of lower leaves cleaning the stems and recutting the base before placing them in the solution were done. After recording the fresh weight of the flowers each cut flower was placed in

100 ml conical flask containing 2 per cent sucrose solution freshly prepared by using distilled water and sucrose. Observations were recorded on uptake of vase solution, fresh weight of flower water balance and vase life.

3.4.1 Uptake of vase solution (ml)

The amount of vase solution in the bottle was measured daily. The difference between the consecutive volume of vase solution represents the uptake of vase solution and recorded in milliliters (ml).

3.4.2 Fresh weight of flower

The weight of flower, weighed before keeping for vase life studies and weighed daily represents the fresh weight of flowers and expressed in grams.

3.4.3 Water balance

The difference between the uptake of solution and the transpirational loss which is the water balance in the flower was recorded.

3.4.4 Vase life in days

The point of termination of vase life varies from the first sign of wilting or fading to the total death of all flowers, with all the intermediate values between these points (Halevy and Mayak, 1979). Withering and senescence

of more than 50 per cent of the flowers were considered to be the end of the potential useful longevity of the flower and the number of days taken to reach this stage was recorded by observing the flowers daily, observation of flowers till they were found unfit for continuing in the vase.

EXPERIMENT II.

To increase the longevity of cut flower with chemical preservatives.

Design : Randomised complete Block Design

Treatments : 20

Replications : 3

Treatment details : Sucrose 0, 0.5, 1.0 2.0%.

$Al_2(So_4)_3$ 0, 25, 50, 75, 100ppm

The above chemical preservatives were tried alone, also in combination. The procedure and the observations recorded remained the same as in experiment IA.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the investigation conducted to study the 'Effect of growth regulators on growth and yield of calendula are presented below.

Experiment I : 'Effect of maleic hydrazide, mepiquat chloride and gibberellic acid on growth and yield of calendula'.

4.1 Vegetative parameters

4.1.1 Plant height

The data on plant height as influenced by different growth regulator treatments recorded 60, 75, 90, 105, 120, 135 and 150 days after sowing are presented in Table-I and fig 1.

At 60 days after sowing

The plant height at 60 days after sowing differed significantly due to different growth regulator treatments. The lowest plant height was recorded with maleic hydrazide at 500 ppm (8.33 cm) followed by mepiquat chloride at 100ppm (8.43cm). The highest plant height was recorded with gibberellic acid at 500 ppm (11.36 cm) followed by gibberellic acid at 400 ppm (10.93cm). However in control the plant height recorded was 9.76 cm.

Table.1. Plant height (cm) in Calendula as influenced by different levels of growth regulators.

Treatments	Number of days after sowing						
	60	75	90	105	120	135	150
Maleic hydrazide 50 ppm	9.43	20.82	34.16	37.43	38.67	40.70	42.15
Maleic hydrazide 100 ppm	10.03	20.56	32.73	36.33	37.52	38.96	40.48
Maleic hydrazide 250 ppm	8.59	20.22	30.64	33.00	33.69	34.97	36.29
Maleic hydrazide 500 ppm	8.33	18.47	31.76	33.71	34.78	36.00	37.28
Mepiquat chloride 50 ppm	9.40	20.30	34.89	37.84	38.97	41.45	43.00
Mepiquat chloride 100 ppm	8.43	20.24	34.19	36.83	38.16	40.08	41.72
Mepiquat chloride 250 ppm	9.26	19.01	33.19	36.63	37.91	39.26	41.14
Mepiquat chloride 500 ppm	8.78	16.79	32.25	34.32	35.56	37.27	39.12
Gibberellic acid 50 ppm	9.76	28.43	36.75	39.87	41.66	43.91	45.83
Gibberellic acid 100 ppm	10.61	36.15	40.29	43.67	45.47	47.63	49.48
Gibberellic acid 200 ppm	10.77	35.54	41.62	45.07	46.74	49.37	51.25
Gibberellic acid 300 ppm	8.52	40.08	41.18	45.61	47.49	50.39	52.31
Gibberellic acid 400 ppm	10.93	41.62	45.16	49.10	50.80	53.33	55.20
Gibberellic acid 500 ppm	11.36	41.62	42.03	45.25	47.28	49.61	51.45
Control	9.76	23.70	35.56	37.39	38.21	40.91	42.65
'F'-Test	*	*	*	*	*	*	*
S.Em	0.5108	1.4037	1.3546	1.3344	1.3203	1.2579	1.2948
C.D at 5%	1.4791	4.0655	3.9235	3.8648	3.8239	3.6433	3.7503

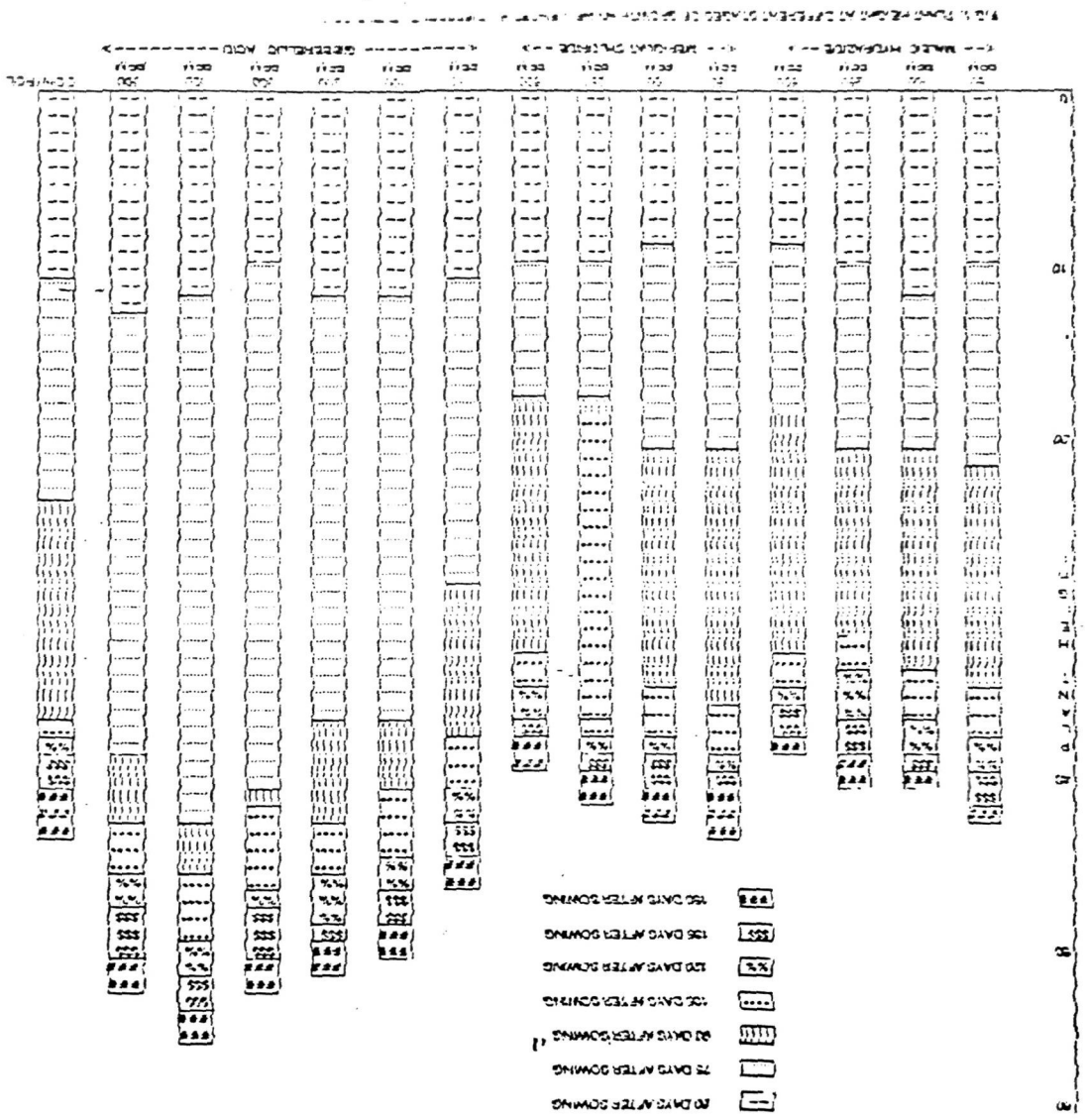

Plate 1 : General view of the crop at pre-blosom stage

Plate 2 : Plants treated with 100 ppm maleic hydrazide

At 75 days after sowing

There was significant difference among the different growth regulator treatments. The lowest plant height was recorded with mepiquat chloride at 500 ppm (16.79cm) followed by maleic hydrazide at 500 ppm (18.47cm) and mepiquat chloride at 250 ppm(19.01 cm). The highest plant height was recorded with gibberellic acid at 400 ppm (40.68cm) and significant differences in height of plants due to various treatments were evident (Table-I).

At 90 days after sowing

Plant height differed significantly among the different growth regulator treatments at 90 days after sowing. The lowest plant height was recorded with maleic hydrazide at 250 ppm (30.64cm). The maximum plant height was recorded with gibberellic acid at 400 ppm (45.16cm) followed by gibberellic acid at 500 ppm (42.03cm). However plant height in control was 35.56 cm.

At 105 days after sowing

Plant height at 110 days after sowing differed significantly owing to different growth regulator treatments. The highest plant was recorded with gibberellic acid at 400 ppm (49.10cm). The lowest plant height was

recorded with maleic hydrazide at 250 ppm (33.0cm), and next best retardant in order to reduce the plant height was maleic hydrazide 500 ppm (33.71 cm) followed by mepiquat chloride at 500ppm (34.62 cm).

At 120 days after sowing

The plant height recorded at 120 days after sowing differed significantly among the different growth regulator treatments. The lowest plant height of 33.69cm was recorded with maleic hydrazide 250 ppm followed by maleic hydrazide 500 ppm (34.78 cm).The maximum plant height (50.80cm) was recorded with gibberellic acid 400 ppm followed by at 300 ppm (47.49 cm).

At 135 days after sowing

The plant height recorded at 135 days after sowing differed significantly among different growth regulator treatments. The lowest plant height was of 34.97 cm was recorded with maleic hydrazide at 250 ppm followed by maleic hydrazide at 500 ppm (36.60cm). The maximum plant height (53.33cm) was recorded with gibberellic acid 400 ppm followed by gibberellic acid at 300 ppm (50.39cm).

At 150 days after sowing

The final plant height recorded at 150 days after

sowing differed significantly among the different growth regulator treatments.

The highest plant height was recorded with gibberellic acid at 400 ppm (55.20cm) followed by gibberellic acid at 300 ppm (52.31cm). The lowest plant height was recorded with maleic hydrazide 250 ppm (36.29cm) followed by maleic hydrazide at 500 ppm (37.28cm). The plant height in untreated (control) was 42.65 at 150 days after sowing.

4.1.2 Number of branches per plant

Data on number of branches per plant as influenced by different growth regulator treatments are presented in Table-2.

At 60 days after sowing

All the different growth regulator treatments differed significantly. The highest number of branches were recorded in gibberellic acid 50 ppm(8.8) followed by gibberellic acid 500ppm (8.13) and gibberellic acid 100ppm (7.56).

At 75 days after sowing

The number of branches differed significantly due to different growth regulator treatments at 75 days after sowing. The maximum number of branches were recorded with

Table - 2. Number of branches per plant in Calendula as influenced by different levels of growth regulators.

Treatments	Number of days after sowing						
	60	75	90	105	120	135	150
Maleic hydrazide 50 ppm	4.80	11.20	11.06	13.50	13.53	14.03	14.23
Maleic hydrazide 100 ppm	5.83	11.00	12.70	13.73	13.76	14.13	14.23
Maleic hydrazide 250 ppm	4.03	9.80	11.73	12.33	12.43	12.90	13.13
Maleic hydrazide 500 ppm	3.66	10.76	12.90	13.50	13.60	14.60	14.63
Mepiquat chloride 50 ppm	3.90	8.23	10.40	10.83	10.90	11.56	11.73
Mepiquat chloride 100 ppm	5.16	7.48	9.90	10.13	10.13	10.80	11.00
Mepiquat chloride 250 ppm	5.20	12.33	14.50	15.00	15.13	15.50	15.80
Mepiquat chloride 500 ppm	6.33	13.56	16.80	18.00	18.03	18.53	18.73
Gibberellic acid 50 ppm	8.80	10.26	11.83	12.66	12.76	13.43	13.56
Gibberellic acid 100 ppm	7.56	10.50	12.43	13.46	13.53	14.00	14.20
Gibberellic acid 200 ppm	6.90	10.26	11.23	12.00	12.16	12.66	12.76
Gibberellic acid 300 ppm	6.40	10.50	12.33	12.86	13.00	13.73	13.93
Gibberellic acid 400 ppm	5.00	10.03	11.73	12.23	12.36	12.86	13.06
Gibberellic acid 500 ppm	8.13	14.26	15.50	16.10	16.40	16.83	17.23
Control	1.60	8.16	9.03	9.36	9.43	9.86	10.13
'F'-Test	*	*	*	*	*	*	*
S.Em	0.8466	0.7889	0.7905	0.8614	0.8738	0.8335	0.8184
C.D at 5%	2.4520	2.2849	2.2897	2.4950	2.5309	2.4142	2.3704

500ppm gibberellic acid (14.26) and the minimum number of branches were recorded with control (8.16).

At 90 days after sowing

All the growth regulator treatments recorded higher number of branches as compared to control (9.03). The highest number of branches per plant was with mepiquat chloride 500 ppm (16.80) and was closely followed by gibberellic acid 500 ppm (15.50) and mepiquat chloride 250 ppm (14.50).

At 105 days after sowing

The number of branches at 105 days after sowing differed significantly owing to different growth regulator treatments. Spraying mepiquat chloride at 500 ppm resulted in the highest number of branches (18.00), followed by gibberellic acid at 500ppm (16.10) and mepiquat chloride 250ppm (15.00). The least number of branches were recorded in control (9.36). The number of branches produced as a result of growth regulator treatments ranged from 10.13 to 18.00.

At 120 days after sowing

All the growth regulator treatments differed significantly. The highest number of branches were recorded

with mepiquat chloride 500ppm (18.03) followed by gibberellic acid 500ppm (16.40). The number of branches recorded in control was 9.43 (Table 2).

At 135 days after sowing

All the growth regulator treatments recorded higher number of branches ranging from 10.80 to 18.53 as compared to control (9.86). The highest number of branches per plant was with mepiquat chloride 500 ppm (18.53) followed by gibberellic acid 500 ppm (16.83) and mepiquat chloride 250ppm (15.50).

At 150 days after sowing

The number of branches differed significantly due to different growth regulator treatments at 150 days after sowing. The maximum number of branches were recorded with 500ppm mepiquat chloride (18.73), followed by gibberellic acid at 500ppm (17.13). The least number of branches were recorded with control (10.13).

4.1.3 Number of nodes per plant at flowering and internodal length at flowering

Data on the number of nodes at flowering and internodal length at flowering as influenced by different growth

Table-3. Number of nodes and internodal length per plant at flowering as in Calendula as influenced by growth regulators.

Treatments	Number of nodes at flowering	Internodal length at flowering (cm)
Maleic hydrazide 50 ppm	17.40	1.73
Maleic hydrazide 100 ppm	17.80	1.65
Maleic hydrazide 250 ppm	16.66	1.78
Maleic hydrazide 500 ppm	18.16	1.73
Mepiquat chloride 50 ppm	15.26	2.05
Mepiquat chloride 100 ppm	17.06	1.76
Mepiquat chloride 250 ppm	17.23	1.68
Mepiquat chloride 500 ppm	16.30	1.79
Gibberellic acid 50 ppm	17.50	1.93
Gibberellic acid 100 ppm	17.10	2.16
Gibberellic acid 200 ppm	17.10	2.25
Gibberellic acid 300 ppm	18.26	2.18
Gibberellic acid 400 ppm	17.20	2.52
Gibberellic acid 500 ppm	19.43	2.26
Control	14.50	2.08
'F' - Test	NS	*
S.Em	-	0.1658
C.D at 5%	-	0.4803

Plate 3 : Plants treated with 100 ppm Gibberellic acid

Plate 4 : Comparison of plants treated with maleic hydrazide (100 ppm) and Gibberellic acid (400 ppm)

regulator treatments are presented in Table-3.

Number of nodes per plant

The maximum number of nodes were recorded with 500 ppm gibberellic acid (19.43) closely followed by 300ppm gibberellic acid (18.26) and 500ppm maleic hydrazide (18.16). The minimum number of nodes among the growth regulator treatment were recorded with 50ppm mepiquat chloride (15.26). However, the number of nodes per plant in case of control was 14.50. The number of nodes as influenced by differeent growth regulator treatments ranged from 15.26 to 19.43. There was no significant difference in the number of nodes per plant at flowering.

Internodal length per plant at flowering

Significant differences were found in internodal length due to different growth regulator treatments. The internodal length decreased with maleic hydrazide and mepiquat chloride treatments while it increased with gibberellic acid treatments.

The minimum internodal length was recorded with maleic hydrazide (1.48cm) and the maximum internodal length was recorded in 400 ppm gibberellic acid (2.52cm) followed by 500 ppm gibberellic acid (2.26cm). However internodal

Table-4. Number of leaves and leaf area at flowering in calendula as influenced by different levels of growth regulators.

Treatments	Number of leaves at flowering	Leaf area cm^2	Average leaf area (cm^2)
Maleic hydrazide 50 ppm	144.43	3664.36	25.37
Maleic hydrazide 100 ppm	165.53	4235.14	25.58
Maleic hydrazide 250 ppm	154.39	4132.86	26.76
Maleic hydrazide 500 ppm	171.86	4416.29	25.69
Mepiquat chloride 50 ppm	138.22	3878.74	28.06
Mepiquat chloride 100 ppm	132.00	3728.96	28.24
Mepiquat chloride 250 ppm	190.75	4654.03	24.39
Mepiquat chloride 500 ppm	219.12	4815.92	21.97
Gibberellic acid 50 ppm	155.36	4308.16	27.73
Gibberellic acid 100 ppm	157.58	4447.47	28.22
Gibberellic acid 200 ppm	148.00	4107.09	27.75
Gibberellic acid 300 ppm	162.21	4202.43	25.90
Gibberellic acid 400 ppm	155.24	4253.10	27.39
Gibberellic acid 500 ppm	203.54	4620.28	22.69
Control	118.03	3448.13	29.21
'F' - Test	*	*	
S.Em	4.8716	67.8766	
C.D at 5%	14.1096	196.5918	

length in control was 2.08cm.

4.1.4 Number of leaves per plant at flowering and leaf area per plant at flowering

Data on the number of leaves per plant at flowering and leaf area per plant at flowering as influenced by different growth regulator treatments are presented in the Table-4.

Number of leaves

The number of leaves per plant differed significantly owing to different growth regulator treatments tried. However, the maximum number of leaves per plant was recorded with 500ppm mepiquat chloride (219.12) and minimum number of leaves per plant (118.03) was with control.

Leaf area

Significant differences were found in leaf area due to different growth regulator treatments. The minimum leaf area was recorded with control (3448.13cm^2) followed by maleic hydrazide at 50ppm (3664.36 cm^2) and the maximum leaf area was recorded with 500 ppm mepiquat chloride (4815.92 cm^2) followed by 250 ppm mepiquat chloride (4654.03 cm^2).

4.2 Flowering characteristics

Number of days taken for first flower opening and for 50 per cent flowering

Data on number of days taken for first flower opening

Table-5. Number of days taken for first flower opening and for 50 per cent flowering in calendula as influenced by different levels of growth regulators.

Treatments	Number of days for first flower opening	Number of days for 50 per cent
Maleic hydrazide 50 ppm	80.53	111.06
Maleic hydrazide 100 ppm	83.90	112.43
Maleic hydrazide 250 ppm	81.82	111.56
Maleic hydrazide 500 ppm	83.87	116.10
Mepiquat chloride 50 ppm	82.86	112.06
Mepiquat chloride 100 ppm	84.86	114.96
Mepiquat chloride 250 ppm	85.06	117.80
Mepiquat chloride 500 ppm	81.73	110.60
Gibberellic acid 50 ppm	79.10	113.43
Gibberellic acid 100 ppm	79.00	113.43
Gibberellic acid 200 ppm	77.53	112.50
Gibberellic acid 300 ppm	76.30	112.93
Gibberellic acid 400 ppm	74.86	113.43
Gibberellic acid 500 ppm	72.46	112.23
Control	79.85	118.80
'F' - Test	*	*
S.Em	1.0333	0.9477
C.D at 5%	2.9928	2.7447

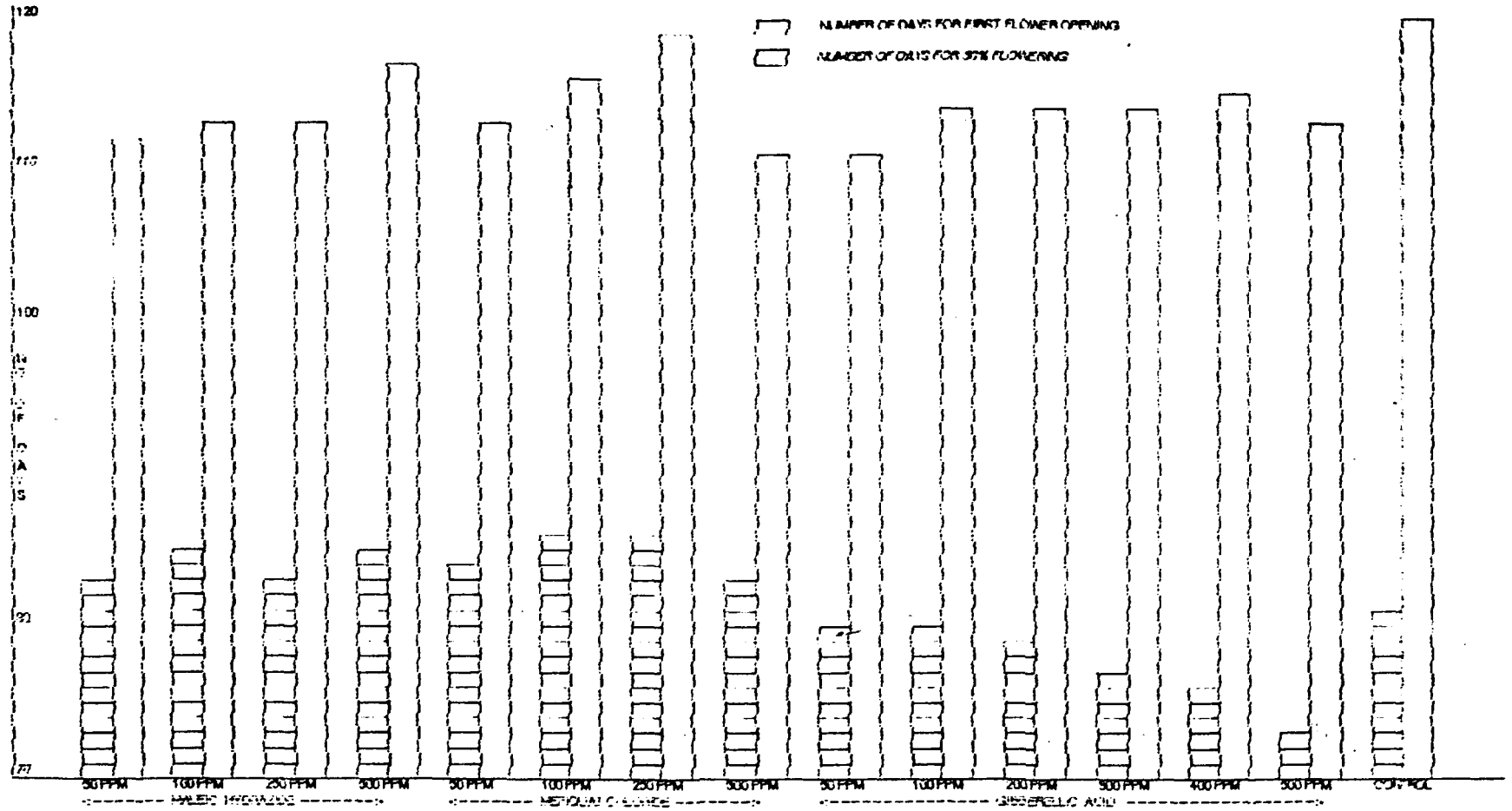

FIG 2 NO OF DAYS FOR FIRST FLOWER OPENING AND FOR 50% FLOWERING AS INFLUENCED BY DIFFERENT LEVELS OF GROWTH REGULATORS

and for 50 per cent flowering as influenced by different growth regulators treatment are presented in Table-5.

4.2.1 Number of days taken for first flower opening

The growth retardant treatments delayed the first flower opening while gibberellic acid has reduced the time to first flower opening. Maximum number of days taken for first flower opening (85.06 days) was with mepiquat chloride, 84.86 days with 100 ppm maleic hydrazide.
Minimum number of days taken for first flower opening (72.46 days) was recorded with 500 ppm gibberellic acid followed by gibberellic acid 400 ppm (74.86 days) and gibberellic acid 300 ppm (76.30 days). However days taken for first flower opening in control was 79.85 days.

4.2.2 Number of days for 50 per cent flowering

The number of days taken for 50 per cent flowering was influenced significantly by different growth regulator treatments. The maximum number of days taken for 50 per cent flowering was with control (118.70 days) and the minimum number of days taken for 50 per cent flowering was with mepiquat chloride 500 ppm (110.60 days). The days taken for 50 per cent flowering due to different growth regulator treatments ranges from 109.46 to 117.80 days (Table-5).

Table-6. Number of flowers per plant and flower yield per plant as influenced by different levels of growth regulators.

Treatments	Number of flowers per plant	Yield of flowers per plant (g)
Maleic hydrazide 50 ppm	22.56	63.10
Maleic hydrazide 100 ppm	23.63	66.18
Maleic hydrazide 250 ppm	23.56	65.98
Maleic hydrazide 500 ppm	18.24	51.08
Mepiquat chloride 50 ppm	24.70	69.16
Mepiquat chloride 100 ppm	24.23	67.84
Mepiquat chloride 250 ppm	21.24	59.47
Mepiquat chloride 500 ppm	23.17	64.18
Gibberellic acid 50 ppm	18.91	52.99
Gibberellic acid 100 ppm	21.81	61.06
Gibberellic acid 200 ppm	23.85	66.79
Gibberellic acid 300 ppm	23.35	65.37
Gibberellic acid 400 ppm	23.54	65.91
Gibberellic acid 500 ppm	23.88	66.88
Control	18.49	51.76
'F' - Test	*	*
S.Em	1.0966	3.0715
C.D at 5%	3.1761	8.8959

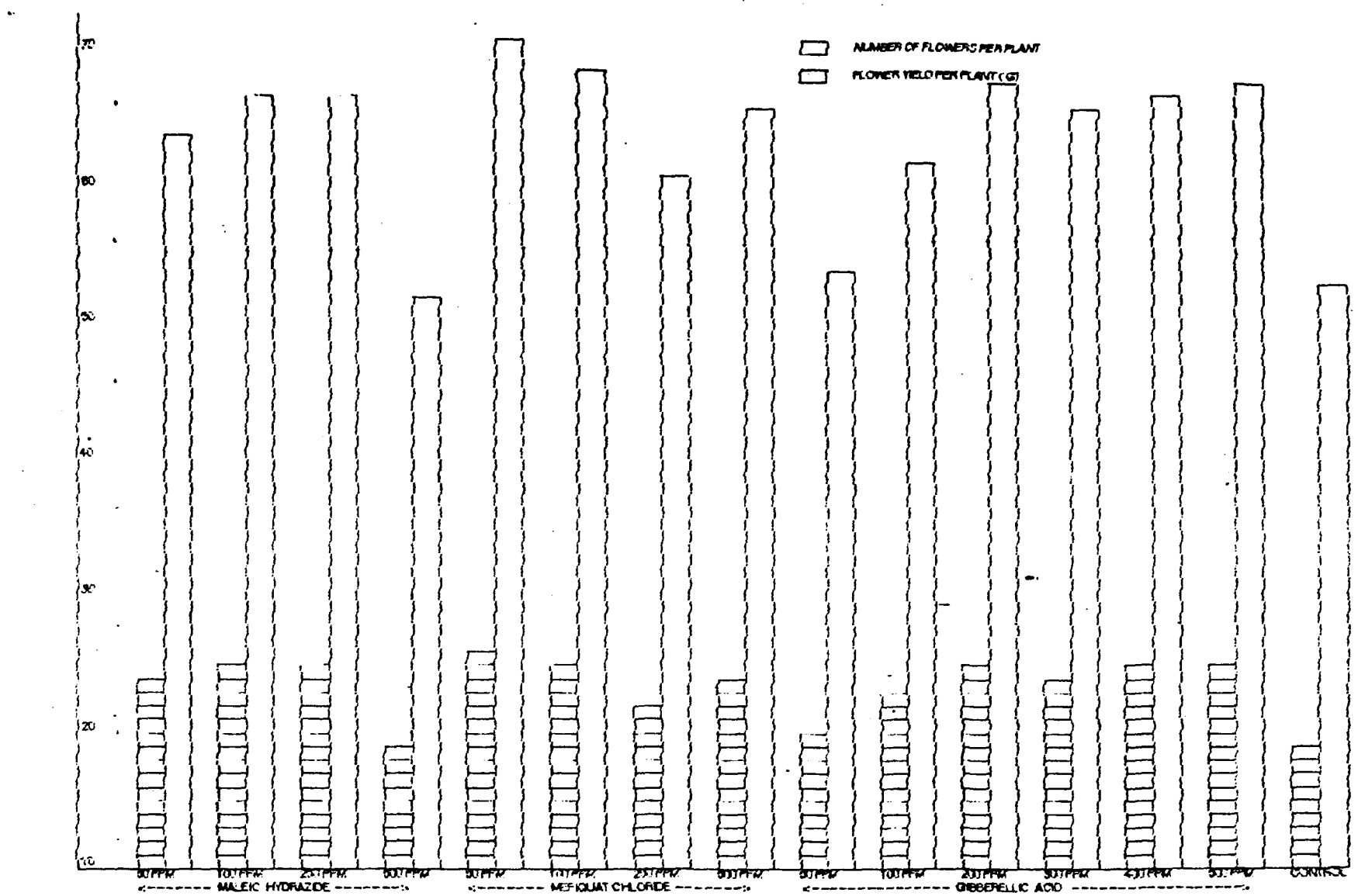

FIG 2. NUMBER OF FLOWERS AND FLOWER YIELD PER PLANT AS INFLUENCED BY DIFFERENT LEVELS OF GROWTH REGULATORS

4.2.3 Number of flowers per plant and yield of flowers per plant

The number of flowers produced per plant and the yield of flowers per plant owing to different growth regulator treatments are presented in Table-6.

Number of flowers per plant

All the growth regulator treatments tried increased the number of flowers per plant in Calendula. Plants sprayed with mepiquat chloride at 50 ppm recorded the highest number of flowers (24.70) followed by mepiquat chloride at 100 ppm (24.23) . However the lowest number of flowers were recorded with maleic hydrazide at 500 ppm (18.24) and in untreated control (18.49).

Yield of flowers

There was significant difference in flower yield per plant owing to growth regulators application. The maximum flower yield was recorded with mepiquat chloride at 50 ppm (69.16g/plant) followed by mepiquat chloride at 100 ppm (67.84 g/plant) and gibberellic acid 500 ppm (66.88 g/plant). The minimum flower yield was recorded with maleic hydrazide at 500 ppm

Table-7. Stem length, peduncle length, flower diameter, dry weight of flowers per plant and dry weight of plant in calendula as influenced by different levels of growth regulators.

Treatments	Stem length (cm)	Peduncle length (cm)	Flower diameter (cm)	Dry wt.of flowers /plant (g)	Dry wt.of plant (g)
Maleic hydrazide 50 ppm	21.08	4.76	6.40	8.55	16.36
Maleic hydrazide 100 ppm	21.43	5.00	6.93	9.46	21.72
Maleic hydrazide 250 ppm	16.60	4.16	6.53	9.19	19.44
Maleic hydrazide 500 ppm	16.39	4.43	5.06	8.89	27.73
Mepiquat chloride 50 ppm	22.26	4.76	5.56	9.46	19.99
Mepiquat chloride 100 ppm	20.67	4.73	5.23	9.52	15.64
Mepiquat chloride 250 ppm	17.80	3.83	6.40	9.31	29.35
Mepiquat chloride 500 ppm	15.82	4.00	6.13	8.34	36.30
Gibberellic acid 50 ppm	27.57	5.53	5.23	6.90	23.82
Gibberellic acid 100 ppm	30.31	6.30	5.70	7.98	26.77
Gibberellic acid 200 ppm	32.35	5.60	5.26	7.33	18.79
Gibberellic acid 300 ppm	34.81	6.70	5.76	6.86	17.45
Gibberellic acid 400 ppm	32.20	6.73	5.36	7.84	22.81
Gibberellic acid 500 ppm	28.41	7.06	5.50	7.37	28.55
Control	24.13	5.36	5.86	7.60	15.68
'F' - Test	*	*	*	*	*
S.Em	1.3562	0.3616	0.3532	0.4770	0.4308
C.D at 5%	3.9279	1.0472	1.0229	1.3816	1.2478

4.2.4 Stem length, peduncle length, flower diameter, dry weight of flowers per plant and dry weight of plant

Data on stem length, peduncle length, flower diameter, dry weight of flowers per plant and dry weight of the plant as influenced by different growth reulator treatments are presented in the Table-7.

Stem length

Growth retardant treatments were effective in decreasing the stem length while growth promoter increased the stem length. The maximum stem length was recorded with gibberellic acid at 300 ppm (34.81cm) followed by gibberellic acid 200 ppm (32.35cm) and gibberellic acid 400 ppm (32,20cm), While the minimum stem length was recorded with mepiquat chloride at 500 ppm (15.82cm) followed by maleic hydrazide at 500ppm (16.39cm) and maleic hydrazide 250 ppm (16.60cm). However is untreated (control) the stem length was 24.13 cm.

Peduncle length

There was significant difference in peduncle length owing to growth regulator spray. The maximum peduncle length was recorded with 500 ppm gibberellic acid (7.06cm) followed by 400 ppm gibberellic acid (6.73cm) and

gibberellic acid 300 ppm (6.70cm). The minimum peduncle length was recorded with mepiquat chloride at 250 ppm (3.83ppm) followed by mepiquat chloride 500 ppm (4.00cm) and maleic hydrazide 250 ppm (4.16cm). However in untreated (control) the peduncle length was 5.36cm.

Flower diameter

There was significant difference in the diameter of the flower owing to growth regulator spray. The maximum flower diameter was recorded with maleic hydrazide 100 ppm (6.93cm) spray followed by maleic hydrazide 250 ppm (6.53cm). The minimum flower diameter was recorded with maleic hydrazide at 500 ppm (5.66cm) followed by 100 ppm mepiquat chloride and 50ppm gibberellic acid (5.23cm).

Dry weight of flowers

There was significant difference in dry weight of flowers per plant due to growth regulator spray. The highest dry weight of flowers per plant was recorded in 100ppm mepiquat chloride (9.52g/plant) followed by 9.46/plant both in 100 ppm maleic hydrazide and 50ppm mepiquat chloride. The lowest dry weight of flowers per plant was recorded in 300 ppm gibberellic acid (6.86g/plant) followed by 50ppm gibberellic acid (6.90g/plant).

Dry weight of the plant

Significant difference in dry weight of plants was observed due to the influence of different growth regulator treatments. Maximum dry weight was recorded with mepiquat chloride a 500 ppm (36.30g) followed by mepiquat chloride at 250 ppm (29.35g) and gibberellic acid at 500 ppm (28.55g). Lowest dry weight was recorded with control (15.68).

4.2.5 Flower longevity and total flowering period

Data on the influence of different growth regulator treatments on longevity of flower and total flowering period are presented in Table-8.

Flower longevity

There was significant difference in flower longevity owing to growth regulator treatments. The maximum flower longevity was recorded with 500 ppm maliec hydrazide (5.80 days) closely followed by 500 ppm mepiquat chloride (5.70 days). The minimum flower longevity was observed in 250ppm maleic hydrazide (4.26days) followed by control (4.73days).

Total flowering period

The total flowering period varied due to growth regulator application and significantly differed, the

Table-8. Flower longevity and total flowering period as influenced by different levels of growth regulators.

Treatments	Longevity of flowers on the plant (days)	Flowering period (days)
Maleic hydrazide 50 ppm	5.13	51.93
Maleic hydrazide 100 ppm	5.30	55.40
Maleic hydrazide 250 ppm	4.26	58.00
Maleic hydrazide 500 ppm	5.80	58.73
Mepiquat chloride 50 ppm	4.93	57.23
Mepiquat chloride 100 ppm	5.60	57.23
Mepiquat chloride 250 ppm	5.40	59.13
Mepiquat chloride 500 ppm	5.70	50.96
Gibberellic acid 50 ppm	5.30	61.26
Gibberellic acid 100 ppm	5.30	69.96
Gibberellic acid 200 ppm	5.63	69.26
Gibberellic acid 300 ppm	5.46	57.66
Gibberellic acid 400 ppm	5.23	54.16
Gibberellic acid 500 ppm	5.46	55.33
Control	4.73	53.33
'F' - Test	*	*
S.Em	0.2984	0.6347
C.D at 5%	0.8642	1.8384

maximum flowering period was recorded with 100ppm gibberellic acid (69.96 days) which closely followed by 200 ppm gibberellic acid (69.26 days). The minimum flowering period was with 500 ppm mepiquat chloride (50.96 days) followed by 50 ppm maleic hydrazide (51.93 days). However total flowering period in control was 53.33 days. The increase of total flowering period ranged upto 15 days owing to the application of growth regulators.

4.2.6 Vase life of cut flowers of Calendula

Data on fresh weight of flowers, uptake of solution ; transpirational loss, water balance and vase life as influenced by different growth regulator treatments along with 2 per cent sucrose solution are presented in Table-9 and 10.

Fresh weight

In general the fresh weight of flowers was found to increase upto 3 days and thereafter a declining trend was observed. The different growth regulator treatments along with 2 per cent sucrose differed significantly in fresh weight during first day later on there were no significant differences in fresh weight from third to seventh day. On the first day maximum fresh weight was recorded with the gibberellic acid at 300 ppm (7.45g) followed by 50ppm

Table-9 Fresh weight of flowers, uptake of solution of calendula flower as influenced by different levels of growth regulators.

Treatments		Fresh weight of flowers (g)				Uptake of solution (ml)			
		Days				Days			
		1	3	5	7	1	3	5	7
Maleic hydrazide	50 ppm	3.90	4.60	3.90	3.00	2.25	4.40	2.15	1.65
Maleic hydrazide	100 ppm	5.00	5.45	4.20	3.15	3.20	5.20	2.05	1.70
Maleic hydrazide	250 ppm	4.80	4.90	3.70	2.80	2.80	4.30	2.00	1.95
Maleic hydrazide	500 ppm	5.00	4.90	3.65	2.75	2.50	3.40	1.75	1.70
Mepiquat chloride	50 ppm	3.40	3.60	2.90	2.45	1.75	2.55	1.55	1.55
Mepiquat chloride	100 ppm	4.40	4.05	3.25	2.60	2.90	3.60	1.60	1.60
Mepiquat chloride	250 ppm	2.70	3.10	2.50	2.15	1.45	3.00	1.40	1.40
Mepiquat chloride	500 ppm	3.55	3.85	3.15	2.45	1.95	3.15	1.75	1.65
Gibberellic acid	50 ppm	5.35	5.40	4.30	3.45	2.75	4.95	2.40	2.30
Gibberellic acid	100 ppm	3.60	3.65	2.60	1.95	2.05	3.05	1.80	1.70
Gibberellic acid	200 ppm	4.05	4.55	3.55	2.75	2.45	4.15	2.00	1.95
Gibberellic acid	300 ppm	7.45	6.15	4.60	3.45	3.55	3.70	1.95	2.10
Gibberellic acid	400 ppm	2.55	2.85	2.20	1.70	1.65	2.75	1.70	1.60
Gibberellic acid	500 ppm	3.50	3.45	2.80	2.20	2.15	3.75	2.05	2.25
Control		3.55	3.30	2.85	2.25	2.80	3.85	1.90	2.05
'F' Test		*	NS	NS	NS	NS	NS	NS	NS
S.EM		0.6103	-	-	-	-	-	-	-
C.D at 5%		1.7650	-	-	-	-	-	-	-

gibberellic acid (5.35g). The lowest fresh weight was recorded with gibberellic acid 400ppm (2.55g) followed by 250 ppm mepiquat chloride (2.70g). On the third day the maximum fresh weight was recorded with 300 ppm gibberellic acid (6.15g) and the minimum fresh weight was recorded with gibberellic acid at 400ppm (2.85g). On the fifth day the maximum fresh weight was recorded with 300 ppm gibberellic acid (4.60g) and the least was with 400ppm gibberellic acid (2.20g). On the seventh day the maximum fresh weight was recorded with 300ppm gibberellic acid (3.45g) field spray and the lowest fresh weight was recorded with 400 ppm gibberellic and (1.70g).

Uptake of solution

There was increasing trend in uptake of solution by the cut flowers in the beginning and later declining trend was observed. However, there was no significant decrease in uptake of solution. On the first day the uptake of solution was maximum in 300ppm gibberellic acid (3.55ml) followed by 100ppm maleic hydrazide (3.20ml). The minimum uptake was found in 250ppm mepiquat chloride (1.45ml) followed by 400ppm gibberellic acid (1.65ml). On the third day maximum uptake of solution was recorded with 100ppm maleic hydrazide (5.20ml) followed by 50ppm gibberellic acid The

minimum uptake of solution was recorded with 50ppm mepiquat chloride (2.55ml) followed by 400ppm gibberellic acid (2.75ml). On the fifth day the uptake of solution was maximum with 50ppm gibberellic acid (2.40ml) followed by 50ppm maleic hydrazide (2.15ml). The minimum uptake was with 250ppm mepiquat chloride (1.40ml) followed by 50ppm mepiquat chloride(1.55ml). On the seventh day the maximum uptake was with 50ppm gibberellic acid (2.30ml) followed by 500ppm gibberellic acid (2.25ml). The minimum uptake was with 250ppm mepiquat chloride (1.40ml) followed by 50ppm mepiquat chloride (1.55ml).

Transpirational loss

The transpirational loss was high in the first three days of the study and thereafter a declining trend was noticed. The different growth regulator treatments along with 2 per cent sucrose differed significantly in transpirational loss during first three days of the vase life. On the first day maximum transpirational loss was found in 300ppm gibberellic acid (2.60 ml) followed by 100 ppm mepiquat chloride (0.91ml) followed by 400 ppm in 250ppm mepiquat chloride (0.90ml) followed by 400ppm gibberellic acid(1.05ml) and 50ppm mepiquat chloride (1.10ml). On the third day the maximum transpirational loss of water observed in 300ppm gibberellic acid (5.95ml) and was followed by

Table-10. Transpirational loss water balance and vase life of calendula flowers as influenced by different levels of growth regulators.

Treatments		Transpirational loss (ml)				Water balance (ml)				Vase life
		Days				Days				(Days)
		1	3	5	7	1	3	5	7	
Maleic hydrazide	50 ppm	1.45	4.50	2.85	2.55	0.95	0.50	-1.25	-0.95	3.00
Maleic hydrazide	100 ppm	2.25	5.70	3.30	2.75	0.90	-0.80	-1.20	-0.90	3.00
Maleic hydrazide	250 ppm	1.90	5.10	3.20	2.85	0.80	-0.90	-1.25	-0.80	3.00
Maleic hydrazide	500 ppm	1.70	4.30	3.00	2.60	0.65	-0.45	-0.70		3.00
Mepiquat chloride	50 ppm	1.10	3.00	2.25	2.00	0.60	-0.95	-0.80		3.00
Mepiquat chloride	100 ppm	2.30	4.55	2.40	2.25	0.55	-0.15	-0.60		3.00
Mepiquat chloride	250 ppm	0.90	3.15	2.00	1.95	0.60	-0.35	-0.70	-0.[illegible]	3.00
Mepiquat chloride	500 ppm	1.35	3.45	2.45	2.35	0.80	-0.75	-1.10	-0.90	3.66
Gibberellic acid	50 ppm	1.95	5.70	3.50	3.15	0.75	-0.70	-1.05	-0.65	4.00
Gibberellic acid	100 ppm	1.30	3.75	2.75	2.35	0.75	-0.70	-1.00	-0.75	3.66
Gibberellic acid	200 ppm	1.70	4.40	3.00	2.75	0.95	-2.75	-1.55	-1.15	3.33
Gibberellic acid	300 ppm	2.60	5.95	3.50	3.25	0.60	-0.10	-0.65	-0.50	3.66
Gibberellic acid	400 ppm	1.05	3.05	2.35	2.10	0.60	-0.65	-0.65	-0.60	3.00
Gibberellic acid	500 ppm	1.55	4.40	2.70	2.85	0.65	-0.95	-0.45	-0.60	3.66
Control		2.10	4.80	2.35	2.65	0.8	0.20	-0.70	-0.90	3.00
'F' Test		*	*	NS	NS					
S.EM		0.2496	0.5477	-	-					
C.D at 5%		0.7219	1.5839	-	-					

100ppm mepiquat chloride and 50ppm gibberellic acid (5.70ml). The minimum loss was with in the field spray of 50ppm mepiquat chloride (3.00ml) and was followed by 400ppm gibberellic acid(3.05ml) and 250 ppm mepiquat chloride(3.15ml). On the fifth day the transpirational loss was maximum in 50ppm and 300ppm gibberellic acid(3.50ml) followed by 100 ppm maleic hydrazide (3.30ml) and 250ppm maleic hydrazide(3.20ml). The minimum loss resulted owing to 250 ppm mepiquat chloride (2.00ml) followed by 2.35ml loss in control and gibberellic acid sprays. On the seventh day the maximum transpirational loss was recorded in 500 ppm gibberellic acid (3.25ml) followed by 500ppm gibberellic acid and 250 ppm maleic hydrazide (2.85ml). The minimum loss was recorded in 250 ppm mepiquat chloride (1.95ml) closely followed by 50ppm mepiquat chloride (2.00ml) and 400 ppm gibberellic acid (2.10ml) sprays in the field.

Water balance

There was positive water balance on the first day thereafter a negative water balance was observed. On the first day maximum water balance was recorded with 50ppm maleic hydrazide and 200ppm gibberellic acid (0.95ml) followed by 100ppm maleic hydrazide (0.90ml). The minimum water balance was recorded with 100ppm mepiquat chloride

(0.55ml) followed by 250 ppm mepiquat chloride and 300ppm gibberellic acid (0.66ml).

On the third day a postiive water balance was maintained only in mepiquat chloride 50ppm (0.50ml) and in control (0.20ml), however, negative water balance was noted in other treatments.

Vase life (days)

The longest vase life of 4.0 days was recorded with field spray of 50 ppm gibberellic acid and 2 per cent sucrose vase solution followed by 500ppm mepiquat chloride, and 100, 300, and 500ppm gibberellic acid (3.66 days). However there was not much influence of field spray of growth regulators on vase life in other treatments tried. An increase of vase life by 1.0 day (25 per cent) was recorded owing to gibberellic acid at 50ppm field spray and with 2 per cent sucrose as vase solution. The least vase life of 3.0 days was recorded in control and other treatments tried.

4.3 Experiment - II

Vase life of cut flowers of Calendula as influenced by different chemical preservatives.

Data on fresh weight of flowers, uptake of solution,

Table 11. Fresh weight of flowers, uptake of solution as influenced by different preservatives.

Treatments	Fresh weight of flowers (g)			Uptake of solution(ml)		
	Days			Days		
	1	3	5	1	3	5
Sucrose 0.5%	2.86	2.23	1.13	4.66	1.56	1.06
Sucrose 1.0%	2.53	1.90	0.93	4.16	1.33	0.93
Sucrose 2.0%	2.70	2.13	1.10	3.73	1.33	0.90
Aluminimum Sulphate 25ppm	3.90	3.33	2.13	5.73	3.03	1.66
Aluminimum Sulphate 50ppm	3.50	2.86	1.96	4.86	2.63	1.16
Aluminimum Sulphate 75ppm	4.36	3.56	2.90	5.80	3.06	1.13
Aluminimum Sulphate 100ppm	5.30	4.30	2.93	7.30	3.83	1.66
Sucrose 0.5% + Aluminium Sulphate 25ppm	2.80	2.20	1.06	4.80	2.33	1.00
Sucrose 0.5% + Aluminium Sulphate 50ppm	3.10	2.80	1.86	4.33	2.23	0.83
Sucrose 0.5% + Aluminium Sulphate 75ppm	4.20	4.10	3.46	5.86	3.16	1.10
Sucrose 0.5% + Aluminium Sulphate 100ppm	5.43	4.50	4.00	7.60	3.93	1.80
Sucrose 1.0% + Aluminium Sulphate 25ppm	2.30	1.93	1.33	3.23	1.96	0.83
Sucrose 1.0% + Aluminium Sulphate 50ppm	4.30	3.83	3.10	6.76	3.93	1.86
Sucrose 1.0% + Aluminium Sulphate 75ppm	4.93	4.76	3.93	7.43	5.10	2.46
Sucrose 1.0% + Aluminium Sulphate 100ppm	2.60	2.06	1.46	2.33	2.86	2.46
Sucrose 2.0% + Aluminium Sulphate 25ppm	2.80	2.50	1.96	4.66	3.26	1.70
Sucrose 2.0% + Aluminium Sulphate 50ppm	4.13	3.70	3.13	6.23	3.80	2.36
Sucrose 2.0% + Aluminium Sulphate 75ppm	4.30	4.00	2.93	7.13	5.56	2.53
Sucrose 2.0% + Aluminium Sulphate 100ppm	4.36	4.03	3.20	7.06	5.36	2.40
Control	3.60	2.80	1.70	6.46	3.40	2.06
'F' test	*	*	*	*	*	*
S.Em	0.5869	0.5616	0.5589	0.7473	0.4871	0.2663
C.D at 5%	1.6269	1.5566	1.5492	2.0713	1.3500	0.7383

transpirational loss, water balance and vase life are presented in the Table-11 and 12.

Fresh weight

With the addition of chemical preservatives there was in fresh weight from the first day onwards. On the first day the maximum fresh weight was recorded with sucrose 0.5 per cent + Aluminium sulphate 100 ppm (5.43g) whereas the minimum fresh weight was recorded in sucrose 1 per cent + $Al_2(So4)_3$ 25 ppm followed by 2.53 g in sucrose 1 per cent alone however in control the fresh weight was 3.60g. On the third day the maximum fresh weight (4.76g) was recorded with sucrose 1 per cent + Aluminimum Sulphate 75ppm followed by sucrose 0.5 per cent + Aluminium Sulphate 100 ppm (4.50g). The minimum fresh weight was recorded with one per cent sucrose alone (1.90g) and closely followed by sucrose 1.0 percent + aluminimum sulphate 25ppm (1.93g). On the fifth day highest fresh weight was recorded with sucrose 0.5 per cent + Aluminium Sulphate 100 ppm (4.00g) followed by Sucrose 1 per cent + Aluminimum Sulphate 75ppm (3.93g). The minimum fresh weight was recorded with one percent sucrose alone (0.93g) which was followed by sucrose 0.5 per cent + Aluminium sulphate 25 ppm (1.06g). However, in control the least fresh weight was recorded (1.70g).

Uptake of solution

With respect to the uptake of solution by flowers a decreasing trend was observed. On the first day of vase life the uptake of solution was highest in treatment with sucrose 0.5 per cent + Aluminium Sulphate 100 ppm (7.60ml) and was closely followed by sucrose 1.0 per cent + $Al_2(So_4)_3$ 100 ppm (2.33ml) followed by sucrose 1.0 per cent + $Al_2(So_4)_3$ (3.23ml) and sucrose alone at 2.0 per cent (3.73ml). On the third day the maximum uptake of solution was recorded with sucrose 2.0 per cent + $Al_2(So_4)_3$ 75 ppm (5.10ml). The minimum uptake of solution was with sucrose 1.0 and 2.0 per cent (1.33ml) followed by Sucrose 1.0 per cent + $Al_2(So_4)_3$ 25 ppm (1.96ml). On the fifth day of the study the highest uptake of solution was recorded with sucrose 2.0 per cent + $Al_2(So_4)_3$ 75ppm (2.53ml) followed by sucrose 1.0 per cent + $Al_2(So_4)_3$ 75ppm and sucrose 1.0 per cent + $Al_2(So_4)_3$ 100ppm (2.46ml).

Transpirational loss

In the Postharvest treatments of chemical preservatives, there was decrease in transpirational loss of water. On the first day the maximum transpirational loss was with Aluminium sulphate alone at 100 ppm (7.16ml) followed by sucrose 0.5 per cent + $Al_2(So4)_3$ 100ppm

Table 12. Transpirational loss, water balance and vase life as influenced by different preservatives.

Water	Transpirational loss(ml)			Water Balance(ml)			Vase life(Days)
	Days			Days			
	1	3	5	1	3	5	
Sucrose 0.5%	5.16	2.20	1.83	-0.50	-0.33	-0.43	2.66
Sucrose 1.0%	4.63	1.96	1.63	-0.46	-0.63	-0.70	2.66
Sucrose 2.0%	4.26	1.90	1.66	-0.53	-0.56	-0.43	2.66
Aluminimum Sulphate 25ppm	5.83	3.60	2.03	-0.23	-0.56	-0.70	2.66
Aluminimum Sulphate 50ppm	4.90	3.26	1.50	-0.36	-0.60	-0.33	2.33
Aluminimum Sulphate 75ppm	5.70	3.86	0.93	-0.63	-0.80	-0.30	2.33
Aluminimum Sulphate 100ppm	7.16	4.83	1.83	-0.13	-0.66	-0.16	2.66
Sucrose 0.5% + Aluminium Sulphate 25ppm	5.20	2.93	1.70	-0.40	-0.60	-0.70	2.66
Sucrose 0.5% + Aluminium Sulphate 50ppm	4.60	2.63	1.46	-0.33	-0.40	-0.63	2.33
Sucrose 0.5% + Aluminium Sulphate 75ppm	5.86	3.60	1.33	-0.33	-0.43	-0.23	2.33
Sucrose 0.5% + Aluminium Sulphate 100ppm	6.56	4.86	1.26	-0.43	-0.93	-0.53	3.00
Sucrose 1.0% + Aluminium Sulphate 25ppm	3.40	2.13	1.33	-0.16	-0.66	-0.50	2.66
Sucrose 1.0% + Aluminium Sulphate 50ppm	5.63	4.40	1.33	1.06	-0.46	-0.46	3.00
Sucrose 1.0% + Aluminium Sulphate 75ppm	6.46	5.33	1.70	0.96	-0.23	-0.43	4.33
Sucrose 1.0% + Aluminium Sulphate 100ppm	2.20	3.40	2.66	0.40	-0.53	-0.60	4.33
Sucrose 2.0% + Aluminium Sulphate 25ppm	4.10	3.56	1.46	0.56	-0.33	-0.23	3.00
Sucrose 2.0% + Aluminium Sulphate 50ppm	5.23	4.33	1.83	1.06	-0.53	-0.53	4.33
Sucrose 2.0% + Aluminium Sulphate 75ppm	6.33	5.86	1.93	0.80	-0.30	-0.33	4.33
Sucrose 2.0% + Aluminium Sulphate 100ppm	6.40	5.76	2.23	0.66	-0.40	-0.16	4.33
Control	6.50	4.20	2.30	-0.10	-0.80	-0.23	2.66
'F' test	*	*	*				
S.Em	0.6482	0.5123	0.2722				
C.D at 5%	1.7968	1.1000	1.7544				

(6.56ml) and control (6.50ml). The minimum transpirational loss was recorded with sucrose 1.0 per cent + $Al_2(So_4)_3$ (2.20ml) followed by sucrose 1.0 per cent + $Al_2(So_4)_3$ 100 ppm (2.20ml) followed by sucrose 1.0 per cent + $Al_2(So_4)_3$ 25 ppm (3.40ml) and sucrose 2.0 per cent + $Al_2(So_4)_3$ (4.10ml). On the third day the maximum transpirational loss was recorded with sucrose 2.0 per cent + $Al_2(So_4)_3$ 75ppm (5.86ml) followed by sucrose 2.0 per cent + $Al_2(So_4)_3$ 100ppm (5.76ml) and sucrose 1.0 per cent + $Al_2(So_4)_3$ 75ppm (5.33ml). on the fifth day the highest transpirational loss was recorded with sucrose 1.0 per cent + $Al_2(So_4)_3$ (2.66ml) followed by control (2.30ml) and sucrose 2.0 per cent + $Al_2(So_4)_3$ 100ppm (2.23ml). The lowest transpirational loss was recorded with $Al_2(So_4)_3$ alone at 75ppm (0.94ml) followed by sucrose 0.5 per cent + $Al_2(So_4)_3$ 100ppm (1.26ml) and sucrose 0.5 per cent + $Al_2(So_4)_3$ 75ppm sucrose 1.0 per cent + $Al_2(So_4)_3$ 25 ppm and sucrose 1.0 per cent + $Al_2(So_4)_3$ 50 ppm (1.33ml).

Water Balance

In general a negative water balance was observed in different treatments. On the first day highest water balance was recorded with sucrose 1.0 per cent + $Al_2(So_4)_3$ 50ppm and sucrose 2.0 per cent +$Al_2(So_4)_3$ 50 ppm (1.06ml). Lowest water balance was recorded with $Al_2(So_4)_3$ alone at

75ppm (-0.63ml) the different ~~in the~~ treatments tried exhibited a negative water balance on the first day, thereafter all the treatments showed negative water balance during the study.

Vase life (days)

The Vase life of flowers were not much influenced by the chemical preservatives. The maximum vase life of 4.33 days was recorded with sucrose 1.0 per cent $Al_2(So_4)_3$ 75ppm, sucrose 1.0 per cent + $Al_2(So_4)_3$ followed by sucrose 1 per cent + $Al_2(So_4)_3$ 50ppm and sucrose 2 per cent + $Al_2(So_4)_3$ 75ppm (3.0 days), However in other treatments alone and in combination there was not much difference in vase life period owing to the different concentrations and preservatives tried. The least vase life (2.66) days was recorded with control and other treatments. The chemical preservatives tried did not influence much in extending vase life of cut calendula. However the enhanced vase life was 50 per cent more than control.

DISCUSSION

V DISCUSSION

Growth regulators play a significant role in modifying growth and flowering of plants, they change both the morphology and physiology of plants. Their effects vary with plant species, variety, concentration used, frequency of application and various other factors which influence the uptake and translocation of the chemical. Growth regulators are extremely important and valuable in industry manipulating growth and flowering of many ornamental plants.

A popular use of growth regulators is to modify the plant growth which is particularly important in floricultural crops. However, other plant processess and traits can be influenced by the application of exogenous growth regulators. Annuals need stem elongation control under the following conditions, vigours cultivars, generous fertilization programmes, successful disease control, optimum night temperatures ample water and possible crowding of plants, to increase production for financial reasons. However, there are instances where in growth promoters are employed to increase the stem length and peduncle length particularly in crops grown for cut flower purpose.

The results of the present investigation on 'Effect of

growth regulators on growth and yield of Calendula cv. Orange King' are discussed in this chapter.

5.1 Growth attributes

The various growth regulators tried in the present study have successfully influenced the plant height in comparison to control. A steady decrease in plant height was recorded with retardants and an increase in plant height was recorded with increased concentrations of growth promoter. The highest reduction in plant height was obtained at various stages of plant growth with 250 ppm maleic hydrazide followed by 500ppm of mepiquat chloride. The lowest height (36.29cm) reduction was caused by 250ppm maleic hydrazide. The reduction in height seems to have released the lateral buds from apical dominance and hence an increase in number of lateral branches was observed. Similar results were recorded in chrysanthemum Lemper, 1964, Sen and Naik , 1977; Sen and Maharana, 1972; Lindstrom and Tolbert, 1960; Menhenett, 1977; 1985; Dipnar, 1986; Shawreb and Qrunleh, 1988), in Calendula, China aster (Bose, 1965) in China aster (Jauhari and Amarjit, 1960; Narayana Reddy, 1978; Narayana Gowda, 1985 and Lal and Mishra, 1986), in marigold (McConnel and Struckmeyer, 1970).

in Calendula (Jauhari and Amarjit, 1964; Srivastava and Bajpai. 1964 and Armitage et al, 1988.)

In general an increase in plant height was recorded due to increased concentrations of gibberellic acid. The highest plant height was obtained at various stages of plant growth with 400 ppm, followed by 300 ppm of gibberellic acid. Similar results were observed in Chrysanthemum (Bruckel and Wiggans, 1969; Dahab et al,1987; Nagarjuna et al, 1988; Holcomb, 1991; Sen and Maharana, 1972; Shanmugam, et al; 1973), in china aster (Reddy and Sulladmath, 1972) and in marigold (Singh et al., 1991).

Highest number of branches (18.73) were produced due to the application of 500ppm mepiquat chloride followed by 250 ppm mepiquat chloride due to the release of apical dominance. Similar results were obtained by several earlier workers (Cathey, 1967; Jauhari and Anmarjit, 1960; Lemper, 1964; Sen and Maharana, 1972; Powell and Anderson, 1957; Narayana Reddy , 1978; Narayana Gowda, 1985; Lal and Mishra, 1986; Kumara, 1987; Shawareb and Qrunfleh, 1988)

Giberellic acid spray also resulted in more number of branches compared to control . The highest number of branches (17.23) were found in 500 ppm gibberellic acid.

Similar results were obtained in china aster (Reddy and Sulladmath, 1972;) in marigold (Singh, et al., 1991) in chrysanthemum (Nagarjuna et al., 1988; Dahab, et al., 1987; Shanmugam, et al., 1973;).

Various concentrations of growth regulators tried did not influence the number of nodes significantly, however highest number of nodes were recorded with 500 ppm gibberellic acid (19.43) and lowest with control (14.50).

The height in Calendula was reduced due to a reduction in the internodal length. The lowest internodal length (1.48cm) obtained with maleic hydrazide at 250 ppm field spray, it is more effective followed by 100 ppm maleic hydrazide (1.65cm). The internodal length reduction with mepiquat chloride 250ppm (1.68cm) was maximum. Similar results of reduction in internodal length due to the application of growth retardants have been recorded by Culbert (1965) and Bachthaler and Jansen (1985) in Chrysanthemum, Armitage et al., (1987) in calendula, Lal and Mishra (1986), Narayana Reddy (1978) and Narayana Gowda (1985) in China aster and Kumara (1987) in marigold.

The height was increased in calendula due to increase in the internodal length due to application of gibberellic acid. The highest internodal length was (2.52cm) was

obtained with 400ppm gibberellic acid followed by 500ppm gibberellic acid (2.26). Similar reports of internodal elongation have been reported by Dahab et al., (1987), Nagarjuna et al., (1988), Holcomb et al., (1991), Sen and Maharana (1972), Shanmugam et al., (1973) in Chrysanthemum, Reddy and Sulladmath (1972) in China aster, Singh et al., (1989) in marigold.

A significant increase in number of leaves was recorded due to the application of different concentrations of maleic hydrazide, mepiquat chloride and gibberellic acid. Highest number of leaves were obtained due to 500ppm mepiquat chloride followed by 500ppm gibberellic acid. The number of leaves decreased with 250ppm maleic hydrazide while number of leaves in 100 and 200 ppm were on par, However, untreated plants (Control) recorded least number of leaves per plant (118.03). Similar results of increase in number of leaves due to growth regulator treatments were reported by Kumara (1987) and Mcconell and Struckmeyer (1970) in marigold, Masterterz and Campbell (1956), Sen and Maharana (1972) in chrysanthemum, Narayana Reddy (1978) and Narayana Gowda (1985) in China aster.

Spraying growth regulators increased the leaf area significantly. Although 500ppm mepiquat chloride recorded

highest number of leaves, the maximum leaf area was recorded with 250ppm mepiquat chloride followed by 250 ppm gibberellic acid. Similar results of increase in leaf area due to growth regulators were obtained by Dahab et al., (1987), Nagarjuna et al., (1988); Holcomb, et al., 1991, Sen and Maharana (1972), in chrysanthemum.

Flower attributes

The growth regulator effects are also seen in the flowering behaviour like enhanced flowering or delayed flowering, Increase in number of flowers, flower diameter, increased flowering period. However, increase in number of flowers, duration of flowering, longevity of flowers are also desired traits.

Application of 250ppm of mepiquat chloride delayed the time for first flower opening by 5.21 days followed by 100ppm mepiquat chloride (5.01days.) Application of 100ppm of maleic hydrazide delayed flowering by 4.05 days. Delayed flowering was apparently the result of growth inhibition rather than direct effect upon flowering stimulus. Similar results were obtained in china aster (Jauhari and Amarjit, 1960; Narayana Gowda, 1985 and Lal and Mishra, 1986, Reddy and Sulladmath, 1972), in marigold (McConnell and Struckmeyer, 1970; and Kumara, 1987) in chrysanthemum (Sen

and Maharana, 1972, Larsen and Kimmins, 1972, Shanmugam et al., 1973 and Shawareb and Qrunfleh, 1988).

In the present study gibberellic acid at 500 ppm enhanced flowering by 7.39 days followed by 400 ppm chrysanthemum (4.99 days). Similar results were also reported by Maharana (1972), Nagarjuna et al., (1988), Shanmugam et al., (1973), Dahab et al., (1987) in Chrysanthemum, Reddy and Sulladmath (1972) in China aster, Singh et al., (1991) in marigold.

Number of days taken for 50 per cent flowering was influenced by different concentrations of growth regulators tried.

The least number of days for 50 per cent flowering was recorded with 500ppm mepiquat chloride followed by 50 ppm maleic hydrazide. In gibberellic acid 50 ppm the least number of days for 50 per cent flowering evident which was followed by 500ppm gibberellic acid. Similar results of 50 per cent flowering enhancement by gibberellic acid was reported by Nagarjuna et al., (1988) in Chrysanthemum.

Highest number of flowers per plant was obtained due to spray of 50ppm mepiquat chloride (24.70) followed by 100ppm mepiquat chloride (24.33). The number of flowers produced per plant in case of maleic hydrazide 500 ppm was 18.24

which is the least, followed by control 18.49 . Similar result was found in Chrysanthemum (Sen and Maharana, 1972). Similarly decrease in number of flowers at the highest concentration was observed in Chrysanthemum with 1000ppm and 2000ppm maleic hydrazide, 5000 ppm and 10,000 ppm cycocel and 100 ppm and 200 ppm TIBA (Shanmugam, et al., 1973). However in general with gibberellic acid spray treatments the number of flowers increased upto 500ppm.

Mepiquat chloride 50ppm recorded highest yield per plant (69.16g) followed by mepiquat chloride 100 ppm (67.84g). Similarly 50 ppm of maleic hydrazide enhanced yield in calendula (Srivastava and Bajpal, 1964). The lowest yield per plant was recorded with 500 ppm maleic hydrazide (51.08g) followed by control (51.76g). In the present study with increase in gibberellic acid concentration increased the yields were increased, similar such results reported in Chrysanthemum (Dutta, et al., 1993, Shanmugam et al., 1973), concentration of maleic hydrazide (500 ppm) reduced the yields in calendula. Similar result was recorded in Chrysanthemum (Shanmugam, et al., 1973).

There were significant differences in the stem length in all the growth regulator treatments. The longest stem length was with 300 ppm gibberellic acid (34.81cm) followed

by 200ppm gibberellic acid (32.85cm). Similar result was obtained earlier in Chrysanthemum (Dutta, et al., 1993, Dahab, et al., 1987 Sen and Maharana, et al., 1972). This makes the flower suitable as a cut flower because of its long stem. The shortest stem length was with 500 ppm mepiquat chloride, Which makes the plant dwarf, compact and suitable for as a bedding plant.

The peduncle length differed significantly owing to different growth regulater treatments. In general increase gibberellic acid concentration increased the peduncle length. Similar result was earlier recorded in marigold (Singh, et al., 1991) Chrysanthemum (Nagarjuna et al., 1988, Holcomb, et al 1991) China aster (Reddy and Sulladmath 1972). The peduncle length decreased with the growth retardant treatments. Lowest peduncle length was recorded with 250 ppm mepiquat chloride (3.83cm). Similar results were earlier recorded in China aster (Narayana Gowda, 1990, Reddy and Sulladmath, 1972) and in calendula (Armitage, et al., 1987).

The diameter of the flower was also influenced by different growth regulator treatments. Though maleic hydrazide 100 ppm yielded less number of flowers, the diameter was highest (6.93cm). Similar observation was recorded in Chrysanthemum (Sen and Maharana 1972). Growth

retardants usually increase the diameter of the flower as in Chrysanthemum (Shanmugam and Muthuswamy, 1974), China aster (Narayana Gowda, 1992). But contradicting results of reduction of flower diameter with growth retardants was found in China aster (Reddy and Sulladmath, 1972) calendula (Srivastava and Bajpai, 1964).

The dry weight of flowers per plant differed significantly owing to different growth regulator treatments. Highest dry weight of flowers per plant was recorded with 100 ppm maleic hydrazide and 50 ppm mepiquat chloride (9||46) and the lowest dry weight of flowers per plant was recorded with 300 ppm gibberellic acid (6.86g).

In the present study the dry weight of the plant differed significantly due to different growth regulater treatments. The highest dry weight of the plant was recorded with 500 ppm mepiquat chloride but contradicting result was obtained in China aster (Narayana Gowda, 1992). gibberellic acid treatments showed higher plant dry weight compared to control such result was reported in chrysanthemum (Dahab, et al., 1987).

The longevity of flowers on the plant significantly improved with the application of growth regulators. Among the different growth regulator treatments tried maleic

hydrazide at 500 ppm spray was found to prolong the life of flowers to the maximum extent with an increase by 1.07 days over control which was closely followed by mepiquat chloride 500 ppm (0.97 days). The prolonged longevity due to 500 ppm gibberellic acid was 0.73 days over control. Similar results were reported by Reddy and Sulladmath (1972) in china aster, Shanmugam et al(1973), Shamareb and Qrunflech (1988), Buxton and Culbert (1967). Dutta et al (1993) in chrysanthemum, Sen and Sen (1988) in Zinnia and Singh et al. (1989) in marigold.

The total flowering period was exteded over a period of 69.96 days due to the application of 400 ppm gibberellic acid, followed by gibberellic acid at 200 ppm (69.26 days) as compared to control (53.33 days). Earlier workers reported such increased flowering period in marigold (Singh et al, 1991) china aster (Reddy and Sulladmath, 1972) chrysanthemum (Shanmugam et al 1973, Dutta, et al., 1993).

Among growth retardants 250 ppm mepiquat chloride recorded longest flowering period (59.13 days) The use of these results have a practical value in bedding and potted calendula.

Vase life of cut flowers of Calendula

The use of preservative solutions to promote the

quality and to prolong the life of cut flowers has been well known. Flower preservatives are composed mainly of sugars, germicides and acidfiers. Flowers held continously in sugar solutions develop better and have longer life (Aarts, 1957; Marousky, 1971) those in water contribute to deterioration (Faragher et al., 1986). Sucrose fortified flower preservatives have been shown to maintain turgor and prolonged the life of cut flowers (Narayana Gowda, 1986), and also prevent vascular blockage to allow greater flow of solution (Mukhopadhyay, 1980 and Narayana Gowda, 1989). With this idea in view, the present study was taken to determine the effect of different growth regulators on vase life of calendula with 2 per cent sucrose. The different growth regulators in the field spray and two per cent sucrose as vase solution differed significantly in fresh weight only on first day. Initial fresh weight was high in gibberellic acid at 50ppm (5.35g). Greater fresh weight was retained by the flowers obtained from gibberellic acid at 300 ppm (5.35 g). But on third day there was decreasing trend of fresh weight, Similar observations have been reported by Marousky (1971), Rogers (1973) and Narayana Gowda (1990) in china aster. From the fifth day all the treatments showed a decreasing trend in fresh weight.

The uptake of solution was not influenced by the field

spray of growth regulators and sucrose as vase solution in the present vase life study. But the maximum uptake of solution was in 300 ppm gibberellic acid (3.55ml) 250 ppm mepiquat chloride(1.45ml) owing to the spray application.

There was significant difference among the treatments in the transpirational loss of water for the first three days. The minimum transpirational loss was observed in 250 ppm mepiquat chloride (0.90ml)field spray followed by 400 ppm gibberellic acid (1.05ml) on the first day, while on third day the minimum transpirational loss of water was recorded in 50ppm mepiquat chloride(3.0ml). Thereafter the water loss due to transpirtion was on decreasing trend. because of less water uptake.

The water balance remained high on the first day of vase life because of high water uptake and low transpirational loss of water. The highest water balance was recorded with 200ppm gibberellic acid and 50ppm maleic hydrazide (0.95ml).

On the third day, in general the water balance became negative owing to high transpirational loss of water similar such result in chrysanthemum was reported by Meeteren V.Van; (1989), the highest water balance was retained with 50 ppm

maleic hydrazide (0.50ml). From fifth day onwards the water balance decreased further due to low water uptake.

The longest Vase life of 4.0 days was resulted due to field spray of 50 ppm gibberellic acid and two per cent sucrose as Vase solution followed by 3.66 days with field sprays of 500 ppm mepiquat chloride, 100 ppm, 300, 500, ppm gibberellic acid and two per cent sucrose as vase solution. The extension of vase life was due to the effect of gibberellic acid, mepiquat chloride spray in the field which may be the result of the influence of pre-determined 30 per cent potential lasting qualtity of flowers at harvest and the condition under which the crop is grown. Similar results were reported in chrysanthemum (Culber, 1965; Buxton and Culbert, 1967; Shawareb, 1987; and Shawareb and Qrunflech, 1988).

The second investigation was conducted to know the effect of chemical preservatives on the post harvest life of calendula cv. orange king.

In this study sucrose and Aluminimum Sulphate were used at low concentrations to extend the post harvest life of cut calendula flowers.

The primary function of sugars is to supply energy for metabolic processes , in the absence of

photosynthetic sucrose the flowers depend externally on applied sugars for their metabolic requirements.

The effect of sucrose on water uptake by the cut flowers may be species and cultivar specific. The main pre\requistic for long life of cut flowers is on undisturbed water uptake (Aarts, 1957).

Aluminium Sulphate acidfies the holding solution (Halvey and Mayak, 1981; Narayana Gowda; 1986) and keeps it free from micro-oraganisms and helps in preventing the plugging of conducting tissues (Doom et al, 1990) resulting in greater solution uptake (Morousky, 1971) and thereby maintaining freshness of cut flowers for a longer period.

In the present investigation there was steady decrease in fresh weight of flowers. The maximum fresh weight was resulted with the treatment. Sucrose 0.5 per cent + $Al_2(So_4)_3$ 100 ppm (5.43g) and the minimum was recorded with sucrose 1.0 per cent + $Al_2(So_4)_3$ 25ppm (2.3g). Similarly on the third day maximum fresh weight was obtained with sucrose 1.0 per cent + $Al_2(So_4)_3$ 75ppm (4.76g) and the minimum was with sucrose 1.0 per cent alone (1.90g). On the fifth day of vase life a further decrease in fresh weight was recorded. The maximum fresh weight was recorded with sucrose 0.5 per cent + $Al_2(So_4)_3$ 100 ppm (4.0g) and the

minimum fresh weight was recorded with sucrose 1.0 per cent alone. In the present study the chemical preservatives did not increase the fresh weight.

Initial uptake of solution was highest with sucrose 0.5 per cent + $Al_2(SO_4)_3$ 100ppm (7.60ml) followed by sucrose 1.0 per cent + $Al_2(SO_4)_3$ 75 ppm (7.43ml). On the third day the maximum uptake of solution was recorded with sucrose 2.0 per cent + $Al_2(SO_4)_3$ 75ppm (5.56ml) followed by sucrose 2.0 per cent + $Al_2(SO_4)_3$ 100 ppm (5.36ml). On the final day of vase life the maximum fresh weight of cut flowers was retained with sucrose 2.0 per cent + $Al_2(SO_4)_3$ 75 ppm (2.53ml).

Water loss due to transpiration differed significantly due to chemical preservatives. On the first day the maximum water loss due to transpiration was recorded with $Al_2(SO_4)_3$ 100 ppm (7.16ml) and the minimum with sucrose 1.0 per cent + $Al_2(SO_4)_3$ 100 ppm (2.20ml). The maximum water loss due to transpiration on the third day was recorded with Sucrose 2.0 per cent + $Al_2(SO_4)_3$ 100ppm (5.76ml). The minimum loss was recorded with sucrose 2.0 per cent alone followed by sucrose 1.0 per cent. The final day of vase life the highest water loss was noted with sucrose 1.0 per cent + $Al_2(SO_4)_3$ 100 ppm (2.66ml) and in control (2.30ml). The minimum water loss was with $Al_2(SO_4)_3$ 75 ppm (0.93ml) alone. It is clear that

chemical preservatives have not increased the transpirational loss of water since with increase in water loss there is beter uptake of solution. This is clear with negative water balance of cut flowers there is increased transpirational loss of water but accompanied by decrease in uptake of solution there by negative water balance exists right from first day of vase life. Similar such result was reported in Chrysanthememm (Meteeren, V.Van, 1989).

The influence of chemical preservatives on the extention of the vase life of cut calendula flowers was very minimal. An extension of 1.67 days was recorded with sucrose 1.o per cent + Aluminium sulphate 75 ppm. Similar report on extension of vase life with sucrose and $Al_2(SO_4)_3$ was reported in gerbera (Accati and Jona, 1989) China aster (Mantur and Nalawadi, 1989).

The beneficial effects of a growth retardants on calendula plants in the field are seen in height reduction and thus making the plants suitable for bedding purpose, more number flower blooms at a time with increased flower diameter and flower longevity on the plants. While spray of gibberellic acid on calendula plants in the field has benefitted in increased peduncle and stem length making the flower suitable as a cut flower, also resulted in increase in number of flowers, flowering duration and longevity of flowers.

SUMMARY

VI SUMMARY

Investigations on the effect of growth regulators on growth and yield of Calendula (Calendula Officinalis. (L)) cv. Orange King were carried out during the year 1991-92 at the Division of Horticultural Sciences , University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore-560065.

The experiment was carried out in the field adopting randomised complete block design with an objective of assessing the effect of growth regulators on different attributes consisting of both vegetative and flowering characteristics. The results obtained in present investigations are summarised below.

Plant height decreased with an increase in the concentration of growth retardants. Maleic hydrazide at 250 ppm was the most effective in controlling plant height.

Increase in number of branches was obtained with 500 ppm mepiquat chloride, while the lower concentration did not have any significant effect. The maximum leaf area and leaf number resulted due to 500 ppm mepiquat chloride spray.

Days to flowering was delayed upto 5.21 days and 4.0 days with 250 ppm mepiquat chloride and 500 ppm maleic

hydrazide respectively. But gibberellic acid at 500 ppm enhanced flowering by 7.39 days. Days to 50 per cent flowering was maximum with 500 ppm maleic hydrazide and 250 ppm mepiquat chloride thus the plants were in bloom for longer period. But gibberellic acid decreased the days to 50 per cent flowering since it produced flowers at the earlier date.

There was marked and significant increase in production of flowers due to application of growth regulators, mepiquat chloride at 50 ppm was more effective in increasing the number of flowers per plant followed by 100 ppm mepiquat chloride.

The number of flowers increased in general with increase in concentration of gibberellic acid. The maximum yield was recorded with 50 ppm Mepiquat chloride followed by 100 ppm mepiquat chloride.

Stem length, peduncle length, flower diameter, dry weight of flowers, and dry weight of the plant was influenced by the growth regulator treatments. The least stem length and peduncle length was with 500 ppm mepiquat chloride making the plants dwarf compact and suitable for bedding and potting purpose. The longest stem length was recorded with 300 ppm gibberellic acid thus making the

flower suitable as a cutflower for vase purpose. Similarly the peduncle length was maximum with 500 ppm gibberellic acid making the flower suitable for cut flower.

Flower diameter decreased with the increase in the concentration of maleic hydrazide. The maximum flower diameter was with 100 ppm maleic hydrazide. The maximum dry weight of flowers per plant was with 100 ppm mepiquat chloride and the highest dry weight of the plant was recorded with mepiquat chloride at 500 ppm.

Longevity of flowers in the plant improved significantly with the application of growth regulators. Maleic hydrazide at 500 ppm prolonged the life of flowers on the plant to the maximum (5.80 days).

The total flowering period was enhanced due to application of different levels of gibberellic acid. Gibberellic acid at 100 ppm resulted in 69.96 days of total flowering period compared to control of 55.33 days.

In vase life studies the increase in weight of flowers, uptake of solution, transpirational loss and water balance was maximum during the first three days due to growth regulator spray and two per cent sucrose as vase solution. The vase life of cut calendula flowers was increased by 1.0 day with 50 ppm gibberellic acid as field spray and 2.0 per

cent sucrose as vase solution, control recorded 3.0 days of vase life.

The chemical preservatives tried namely sucrose and Aluminium sulphate to extend the vase life of cut calendula flowers did not influence the fresh weight, uptake of solution, transpirational loss and water balance during the vase life period. In studies to improve the vase life with preservatives, sucrose 1 per cent and Aluminium sulphate 75ppm in combination increased the vase life of Calendula by 1.67 days as compared to control. gibberellic acid field spray enhanced vase life by 25 per cent over control.

Based on these results obtained from the present study, spraying of growth regulators such as maleic hydrazide at 250 ppm to obtain dwarf plants and bushy plants. gibberellic acid at 300 ppm to obtain long stem making suitable for floral decoration and mepiquat chloride at 50 ppm for increased number of flowers per plant, can be recommended. Vase life of calendula flower can be increased by one day by keeping the cut flower in sucrose one per cent and aluminium sulphate 75 ppm or 100 ppm.

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* Original not seen.

APPENDICES

APPENDIX - I

The soil of the experimental plot at the Horticultural Research Station, Gandhi Krishi Vignana Kendra was red sandy loam and the physical and chemical composition of the soil are presented below.

1.	Mechanical analysis :		
a)	Coarse Sand (%)	:	35.20
b)	Fine Sand (%)	:	29.80
c)	Silt (%)	:	6.55
d)	Clay (%)	:	26.42
e)	Organic matter (%)	:	1.35
f)	Loss due to acid treatment	:	0.68
2.	Chemical analysis		
a)	Available nitrogen content	:	94 kg/ha
b)	Available phosphorus content	:	18 kg/ha
c)	Exchangeable potassium content	:	132 kg/ha
d)	P^{H}	:	5.5-6.0
e)	Cation exchange capacity (Meq/100 g)	:	8.93
f)	Total exchangeable bases (Meg/100 g)	:	2.38

APPENDIX - II

MEAN MONTHLY METEOROLOGICAL DATA FOR THE PERIOD JANUARY 1994 TO OCTOBER 1994.

MONTHS	TEMPERATURE (°C) Max	Min	SUNSHINE HOURS PER DAY	RELATIVE HUMIDITY (%)	TOTAL RAINFALL (mm)
January	26.6	13.9	8.9	67	2.0
February	28.9	16.7	9.2	76	40.4
March	32.9	17.0	10.2	61	0.0
April	33.2	20.9	9.0	59.5	32.0
May	33.6	21.0	8.5	61	88.3
June	28.9	19.2	6.3	73.5	30.8
July	26.3	18.7	3.2	76.5	92.3
August	27.3	18.8	4.8	72.5	96.2
September	28.5	18.6	7.8	68	113.9
October	27.02	18.03	6.6	75.89	225.6

APPENDIX III

2-4,D	-	2-4 dichloro phenoxy acetic acid
TIBA	-	2,3,5,-Tri-iodo benzoic acid
CCC	-	2-Chloroethyl trimethyl ammonium chloride (Cycocel)
GA	-	Gibberellic acid
MH	-	Maleic hydrazide
8-HQS	-	8-Hydroxy Quinoline Sulphate
8-HQC	-	8-Hydroxy Quinoline Citrate
SADH	-	Succinic acid-2-2-dimethyl hydrazide
2-4-5 T	-	2,4,5 -Trichlorophenoxy acetic acid
IAA	-	Indole acetic acid