The Bioscan 7(4): 733-738, 2012
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, YIELD AND EXPORTABLE QUALITY OF CUT ROSES

S. MUTHU KUMAR*, V. PONNUSWAMI, M. JAWAHARLAL AND A. RAMESH KUMAR
Department of Floriculture and Landscaping, Horticultural College and Research Institute,
Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu.
e-mail: muthuhorts@gmail.com

KEY WORDS
Cut rose
Growth regulators
Yield
Quality
Vase life

Received on :
21.03.2012

Accepted on :
07.07.2012

***Corresponding author**

ABSTRACT

An experiment was conducted to study the influence of various growth regulating chemicals on growth, yield and quality characters of cut rose cv. First Red. The study involved pre harvest spraying with gibberellic acid (50, 100ppm), maleic hydrazide (50, 100ppm) and salicylic acid (25, 50ppm). Gibberellic acid at higher concentration of 100ppm as a preharvest spray excerted a significant influence on crop growth and recorded highest mean values for plant height (76.18cm), stalk length (60.98cm), stem girth (1.66cm) and total chlorophyll content (1.826mg g^{-1}). Similarly the application of gibberellic acid at 100 ppm level drastically increased the quality traits *viz*., mean flower diameter (6.89cm), anthocyanin content (0.1970 OD value) and vase life (2.6 days). Likewise the earliest flowering (40.00 days) was also obtained from preharvest spray of gibberellic acid at 100 ppm. The preharvest application of maleic hydrazide at 100 ppm resulted in the maximum mean number of branches per plant (4.47) and number of flower per plant (16.50).

INTRODUCTION

India has an age old tradition of growing flowers for various aspects. Introduction of green house technology for cultivation of cut flowers in India in the recent past years has changed the scenario of Indian floriculture (Ramalingam, 2008). Huge capital investment has been made by the growers for the production of cut flowers meant to be 100 per cent export oriented. Among the cut flowers grown in India primarily for export, rose tops the area grown under protected conditions (Arun, 1999). Though roses occupy the top places in all international cut flower markets, competitions are very intensive where quality plays a priority role. A fierce competition exists in the international flower market, where Indian roses suffer from poor prices due improper pre and post harvest handling techniques (Patel *et al*., 2007). The causes of this low quality can be primly attributed to non-adoption of scientific management practices namely; low quality planting material, improper nutritional and plant protection practices and lack of technical knowledge regarding the various crop regulation and post harvest practices (Sharma *et al*., 2001). The optimum quality for export of cut roses can be achieved by adopting proper pre and post harvest handling techniques (Chakradhar and Khiratkar, 2003; Hashemabadi and Zarchini, 2010).

Crop production in European countries is mainly hampered by harsh climatic conditions during winter months and import of cut flower for their domestic usage considered much economic than production under protected conditions (Patel *et al*., 2007; Ramalingam, 2008). However, such a situation does not exist in India, where cut roses can be grown round the year without much difficulty.The unfavorable climatic and other conditions in Europe can be cashed by Indian flower growers provided proper pre and post harvest handling practices are followed.

The cultivar First Red is a popular cut rose cultivar valued for its long stalked flowers and leads the group of cultivars grown for cut flowers under closed and protected ecosystems. The variety is known for its sustainability to thrive well under tropical conditions (Patel *et al*., 2007). Eventhough the rose cv. First Red is grown for a long period in some parts of the country, the package of practices for its cultivation under green house presently in vogue are mostly imported from foreign collaborators. Thus, there exists an urgent need to assess the various crop regulation practices which could be adopted under Indian conditions. Among the various crop regulation practices chemical growth regulation offers several advantages like early flowering (Ramesh, 1999; Gupta and Datta, 2001; Ramalingam, 2008), increased yield (Padmapriya, 2000; Chakradhar and Khiratkar, 2003) and improved quality (Chakradhar and Khiratkar, 2003; Alex, 2008). So for these aspects of chemical growth regulations on cut flower crops under protected conditions have not been extensively studied in India. In order to study the effects of various growth regulating chemicals on the yield and export quality of cut rose flowers, the present investigations were undertaken. The experiment was laid out with seven treatments in a randomized block design with three replications.

MATERIALS AND METHODS

Location

Table 1: Effect of plant growth regulators on plant height (cm) of cut rose flowers

Treatments	November'09	December'09	January'10	February'10	Mean
T_0 : Control	49.95	50.92	51.29	52.03	51.05
T_1 : GA_3 50 ppm	62.68	65.19	67.13	68.23	65.81
T_2 : GA_3 100 ppm	74.39	75.93	76.13	78.26	76.18
T_3 : MH 50 ppm	46.43	47.73	49.29	50.19	48.41
T_4 : MH 100 ppm	45.13	46.37	47.57	47.99	46.77
T_5 : SA 25 ppm	50.26	51.37	52.13	52.91	51.67
T_6 : SA 50 ppm	51.53	51.97	52.53	53.19	52.31
Mean	54.34	55.64	56.58	57.54	
SEd	2.093	2.144	2.178	2.217	
CD(0.05)	4.560	4.672	4.746	4.831	

Table 2: Effect of plant growth regulators on number of branches of cut rose flowers

Treatments	November'09	December'09	January'10	February'10	Mean
T_0 : Control	2.58	2.61	2.60	2.61	2.60
T_1 : GA_3 50 ppm	3.79	3.87	3.90	3.87	3.85
T_2 : GA_3 100 ppm	2.86	2.94	2.93	2.96	2.92
T_3 : MH 50 ppm	4.15	4.30	4.21	4.18	4.21
T_4 : MH 100 ppm	4.46	4.39	4.51	4.52	4.47
T_5 : SA 25 ppm	2.65	2.65	2.75	2.79	2.71
T_6 : SA 50 ppm	2.87	2.8	2.90	2.83	2.85
Mean	3.34	3.36	3.40	3.39	
SEd	0.128	0.129	0.129	0.129	
CD(0.05)	0.280	0.281	0.282	0.281	

Table 3: Effect of plant growth regulators on stalk length (cm) of cut rose flowers

Treatments	November'09	December'09	January'10	February'10	Mean
T_0 : Control	35.64	36.52	37.89	39.00	37.26
T_1 : GA_3 50 ppm	47.96	50.29	52.15	54.13	51.13
T_2 : GA_3 100 ppm	59.12	60.14	61.21	63.46	60.98
T_3 : MH 50 ppm	32.20	33.95	35.14	36.02	34.33
T_4 : MH 100 ppm	32.00	32.42	33.27	34.11	32.95
T_5 : SA 25 ppm	36.50	37.13	38.45	38.98	37.76
T_6 : SA 50 ppm	37.54	38.00	39.16	41.19	38.97
Mean	40.14	41.21	42.47	43.84	
SEd	1.558	1.601	1.648	1.704	
CD(0.05)	3.396	3.488	3.592	3.714	

Table 4: Effect of plant growth regulators on flower diameter (cm) of cut rose flowers

Treatments	November'09	December'09	January'10	February'10	Mean
T_0 : Control	4.75	4.83	5.21	5.09	4.97
T_1 : GA_3 50 ppm	5.96	5.64	5.75	5.97	5.83
T_2 : GA_3 100 ppm	6.87	6.84	6.92	6.91	6.89
T_3 : MH 50 ppm	4.45	4.39	4.31	4.40	4.39
T_4 : MH 100 ppm	3.95	3.42	3.81	4.05	3.81
T_5 : SA 25 ppm	4.62	4.89	5.09	5.13	4.93
T_6 : SA 50 ppm	4.73	5.02	5.14	5.28	5.04
Mean	5.05	5.00	5.18	5.26	
SEd	0.194	0.193	0.200	0.203	
CD(0.05)	0.424	0.422	0.436	0.442	

The experiment was conducted during 2009-10 under protected green house conditions in a farmer's field at Hosur, Krishnagiri district, Tamil Nadu, which is geographically situated between 12º43' 0" N latitude and 77º49' 0" E longitude at an altitude of 942m above MSL. The mean minimum and maximum temperature inside the greenhouse during the study period were 12ºC and 35°C respectively and the relative humidity recorded was 75 to 85 per cent.

Crop and variety

The research work was carried out in a Hybrid Tea rose variety 'First Red'. This cultivar is highly suitable for production of long stalked cut flowers for international cut rose markets. Besides, this cv. First Red is primarily suitable for tropical condition.

Growing structure

A greenhouse of 32 x 12 m^2 area in East – West orientation was erected and covered with 800 gauges UV stabilized polythene sheets and the experimental plants were grown.

Methods

Pre harvest spray of growth regulators

The experiment was laid out with seven treatments in a

Table 5: Effect of plant growth regulators on number of days taken for first flowering of cut rose flowers

Treatments	Days
T_0 : Control	52.00
T_1 : GA_3 50 ppm	42.00
T_2 : GA_3 100 ppm	40.00
T_3 : MH 50 ppm	45.33
T_4 : MH 100 ppm	49.33
T_5 : SA 25 ppm	44.00
T_6 : SA 50 ppm	43.00
Mean	44.43
SD	0.759
CD(0.05)	1.654

randomized block design with three replications. One year old uniform budded rose plants of cv. First Red grown on raised beds in greenhouse were used for the study. The study involved preharvest spraying treatments with gibberellic acid (GA) (50, 100ppm), maleic hydrazide (MH) (50, 100ppm) and salicylic acid (SA) (25, 50ppm). The plants were sprayed with chemicals first at 15 days after pruning. This was followed by regular sprays at monthly interval. The plants were sprayed well from top to bottom till dripping wet.

Total chlorophyll content

The total chlorophyll content was determined by following the method of Yoshida *et al*. (1971) and expressed in mg/g of fresh weight.

Vase life

The vase life of cut flower was recorded as per the method suggested by Halevy and Mayak (1979). The vase life of cut flower was evaluated daily by counting the number of days taken for the symptom of shriveling and wilting.

Anthocyanin content

The intensity of anthocyanin pigment was determined by the method described by Kliewer (1970).

Statistical analysis

The statistical analysis was done by adopting the standard procedures of Panse and Sukhatme (1985) and the results were interpreted.

RESULTS AND DISCUSSION

Plant height

The results indicated an increasing trend in plant height with higher concentration of gibberellic acid (Table 1). In the present experiment, GA_3 at 100ppm recorded the maximum mean plant height of 76.18 cm. This may be due to enormous production of new cells beneath the apical dome. The final length of the internode of the plants is determined by the number of cells formed in the sub apical region of the meristem and their subsequent elongation. The cell production of the plants in this region can be stimulated by treating the plants with GA_3, causing them to grow rapidly (Loy, 1977). GA_3 increases the size of the meristematic region and also increases the proportion of cells undergoing cell division. The effect of GA_3 on cell division can be readily accounted for an effect on cell cycle.

Jacqmard (1968) proposed that one of the effects of GA_3 on the plants is to promote the onset of DNA synthesis in cells which are arrested in the G_1 phase of cell cycle. GA_3 reduces the duration of cell cycle by about 30 per cent and primarily does so by reducing length of G_1 phase by 30 per cent and that of S phase by 36 per cent. In addition, GA_3 also cause a change in the place of cell division with the mitotic spindle of dividing cells being reoriented in a longitudinal direction, resulting in vertical files of cells being added on. Thus, the new cells formed contribute to the length of the stem as a result of which a general increase in plant height is observed. This has also been confirmed by the research findings of Singh (1966) in candytuft, Mittal (1967) in dahlia, Reddy (1997) in China aster, Sunitha (2006) in marigold, Dalal *et al*. (2009) in gerbera, Mayoli *et al*. (2009) in ranunculus, Ramdevputra *et al*. (2009) in African marigold, Sainath (2009) in chrysanthemum, Kazaz and Karaguzal (2010) in goldenrod and Rao (2010) in chrysanthemum. Reddy and Sulladmath (1983) noticed a direct correlation between the concentration of GA_3 sprayed and the increased plant height in China aster, Dutta and Seemanthini Ramadas (1997) and Rao (2010) also attributed the increase in plant height of chrysanthemum to the spray of GA_3 which have inturn increased internodal length. Among the different treatments employed maleic hydrazide application significantly reduced the plant height. In maleic hydrazide treatments mean plant height ranged from 46.77 to 48.41 cm. The reduction in the plan height could be because of its inhibitory effect on cell division both in apical and sub apical meristem. These results are in line with findings of Pappiah and Muthuswamy (1978) in *Jasminum auriculatum*, Singh and Rathore (1992) in marigold, Aswath *et al*. (1994); Reddy (1997) in China aster and Navale *et al*. (2010) in chrysanthemum.

Number of branches per plant

A significant influence of various concentrations of maleic hydrazide (MH) on number of branches per plant was observed (Table 2). Among the concentrations, MH at 100 ppm (T_4) recorded the maximum mean number of branches of 4.47 followed by MH at 50ppm (T_3) with 4.21 branches, while control (T_0) recorded lowest mean number of branches per plant (2.60). The increase in number of branches by maleic hydrazide may be possibly due to its inhibitory effects on the cell division in the apical buds which subsequently might have stopped the growth of main axis (Dutta and Seemanthini Ramadas, 1997). This in turn would have accelerated the growth of lateral buds and enhanced the number of branches. These results are corroborated with the finding of Gnyandev (2006) in China aster and Navale *et al*. (2010) in chrysanthemum. With regard to number of branches, GA_3 sprays produced the lowest number of branches where, the increased concentrations however decreased the number of branches. This may be reasoned out to the role of gibberellic acid in stem elongation by the way of increasing internodal length, there could be more utilization of available photosynthates towards the internodal elongation rather than increasing number of branches. Similar results were also obtained by Jauhari and Amarjit (1960), Reddy and Sulladmath (1983) in China aster, Dutta and Seemanthini Ramadas (1997) in chrysanthemum, Ramesh (1999) in China aster and Kazaz and Karaguzal (2010) in goldenrod.

Table 6: Effect of plant growth regulators on stem girth (cm) of cut rose flowers

Treatments	November'09	December'09	January'10	February'10	Mean
T_0 : Control	1.42	1.46	1.40	1.43	1.43
T_1 : GA_3 50 ppm	1.51	1.52	1.49	1.54	1.51
T_2 : GA_3 100 ppm	1.63	1.63	1.68	1.68	1.66
T_3 : MH 50 ppm	1.20	1.24	1.28	1.20	1.23
T_4 : MH 100 ppm	1.18	1.11	1.17	1.16	1.16
T_5 : SA 25 ppm	1.41	1.44	1.50	1.48	1.45
T_6 : SA 50 ppm	1.43	1.46	1.50	1.50	1.47
Mean	1.40	1.41	1.43	1.43	
SEd	0.052	0.053	0.054	0.056	
CD(0.05)	0.114	0.116	0.117	0.122	

Table 7: Effect of plant growth regulators on total chlorophyll content (mg g^{-1}), yield per plant, vase life (days) and Anthocyanin content (OD value) of cut rose flowers

Treatments	Total chlorophyll content (mg g^{-1})	Yield per plant	Vase life (days)	Anthocyanin content (OD value)
T_0 : Control	1.116	8.33	1.1	0.0120
T_1 : GA_3 50 ppm	1.635	10.36	2.1	0.1780
T_2 : GA_3 100 ppm	1.826	11.69	2.6	0.1970
T_3 : MH 50 ppm	1.305	12.69	1.4	0.1060
T_4 : MH 100 ppm	1.291	16.50	1.3	0.0920
T_5 : SA 25 ppm	1.547	9.59	1.6	0.0146
T_6 : SA 50 ppm	1.549	9.97	1.8	0.0149
Mean	1.467	11.30	1.7	0.0978
SEd	0.0531	1.171	0.06	0.0062
CD(0.05)	0.1138	3.577	0.13	0.0134

Stalk length

Among the various levels of chemicals GA_3 100ppm (T_2) recorded the highest mean stalk length of 60.98 cm (Table 3). The lowest mean stalk length of 32.95cm was recorded in maleic hydrazide at 100ppm (T_4). The gibberellic acid application accelerates cell division and longitudinal growths of the cell and plants as a result stem length and plant height was increased simultaneously. The increase in length of flower stalk accounted might be due to an increase in the length of branch. These results are in line with findings of Gnyandev (2006) in China aster and Sainath (2009) in chrysanthemum.

Flower diameter

The flower diameter is the one of the major factor which ultimately contributes to the final quality of the cut flower (Table 4). Among the varying concentrations of chemicals T_2 (GA_3 at 100ppm) recorded the highest mean flower diameter of 6.89cm. GA_3 seems to affect the flower diameter by forming sink in a position where it accumulates and draws the available photosynthates to this site. This can be also attributed for the increased flower diameter obtained in the present experiment (Zieslin *et al*., 1974). Similar results were obtained by Baskaran and Misra (2007) in gladiolus, Sainath (2009) in chrysanthemum and Delvadia *et al*. (2009) in gaillardia. The lowest mean flower diameter of 3.81cm was recorded in T_4 (MH at 100ppm). The reduced flower diameter with maleic hydrazide spray in this experiment could be attributed to its inhibitory effect both on vegetative and reproductive phase. Maleic hydrazide, a metabolic anti-auxin, is well known to induce chromosome breakage, which might itself conceivably contribute to growth inhibition and chromosome breakage in dividing the plant cells and may reduce the overall growth and flower diameter (Haber and White, 1959).

Days taken for first flowering

From the results of the present study, it was found that GA_3 100ppm induced earlier flowering than all other treatments (Table 5). Advanced bud formation and onset of flowering in GA_3 treated rose plants is attributable to early flowering. Increased photosynthesis and respiration along with enhanced carbon-di-oxide fixation in gibberellic acid treated plants also could be responsible for early flowering (Sen and Sen, 1968). The results are line with the finding of Sunitha (2006) in marigold, Sainath (2009) in chrysanthemum, Janowska and Andrzejak (2010) in calla lily. In the present investigation, preharvest application of maleic hydrazide spray delayed the blooming and the delay was severely visualised with increased concentrations. Such delayed flowering nature is supposed to be due to its inhibitory effect on plant growth (Nagarjuna *et al*., 1988; Ramesh, 1999).

Stem girth

There was a significant increase in stem girth in plants receiving gibberellic acid treatment (Table 6). The maximum mean stem girth was recorded in T_2 (GA_3 at 100ppm) with 1.66 cm followed by T_1 (GA_3 at 50ppm) with 1.51cm. The lowest stem girth was recorded in T_4 (MH at 100ppm) which was closely followed by T_3 (MH at 50ppm). The control (T_0) recorded the mean stem girth of 1.43cm. The results are line in with the findings of Ramalingam (2008) in rose and Mayoli *et al*. (2009) in ranunculus.

Total chlorophyll content

Chlorophyll, the pigment controlling photosynthetic system in crop plants was profoundly influenced by growth regulating chemicals (Table 7). GA_3 at 100ppm recorded the highest total chlorophyll content (1.826mg g^{-1}) and this treatment was followed by GA_3 at 50ppm (1.635mg g^{-1}). Similar trend of results of influence of GA_3 on chlorophyll content had been reported by Sairam (1994), Bhatia and Kaur (1997) and Ramalingam (2008).

Flower yield per plant

Obtaining higher yield with enhanced quality is the final objective of any crop regulation practice. Increased yield with high quality finally contributes to the net returns. When flower crops are grown under protected conditions, increased yield per plant and improved quality are very critical to justify the cultivation of the crop under protected condition since a great amount of investment is involved in these type of cultivation. The number of flowers per plant is the major yield contributing factor in cut roses. In the present study (Table 7) the results indicated an increase in the number of flowers per plant when sprayed with maleic hydrazide at 100ppm (16.50). The increase in the number of flowers obtained could be due to the effect of maleic hydrazide on transformation of plants to reproductive phase by modifying greater number of vegetative buds to reproductive shoots. Singh and Rathore (1992) observed an increased number of flowers per plant in marigold by maleic hydrazide application. They attributed the increase in number of flowers per plant due to maleic hydrazide sprays resulting in dense, bushy and stunted growth of treated plants. The results are strengthened by the findings of Gnyandev (2006) in China aster and Navale *et al*. (2010) in chrysanthemum.

Vase life

An increase in vase life of cut rose flowers treated with growth regulating chemicals was observed in distilled water medium (Table 7). GA_3 at 100ppm recorded the maximum vase life of 2.6 days in cut rose cv. First Red in distilled water. An increase in vase life of cut roses due to spray of GA_3 may be attributed to the fact that retardation of senescence by GA_3 is associated with the maintenance of a higher level of RNA in petals and leaves (Goszczynska and Rudnicki, 1988). Similar findings of increase in the vase life of flowers with GA_3 application was reported by Delvadia *et al*. (2009) in gaillardia, Kazaz and Karaguzel (2010) in goldenrod and Rao (2010) in chrysanthemum.

Anthocyanin content

Application of gibberellins showed an increasing trend in the anthocyanin pigment content of flower petals (Table 7). Gibberellic acid application at 100ppm (T_2) recorded the maximum anthocyanin content having an optical density value of 0.1970 which is followed by T_1 (GA_3 at 50ppm) with the optical density value of 0.1780, however both differed significantly from each other. The findings are in agreement with reports of Dahab *et al*. (1987) in chrysanthemum, Goyal and Gupta (1994); Arun (1999) and Ramalingam (2008) in rose.

REFERENCES

Alex, R. 2008. Studies on growth regulation in goldenrod (*Solidago canadensis* L.) to improve flower yield and quality, M. Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Arun. 1999. Chemical regulation of growth and flowering in rose under greenhouse conditions, M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Aswath, S., Gowda, J. V. N. and Murthy, G. M. A. 1994. Effect of growth retardants on growth, flowering and nutrient contents in China aster. *J. Ornam. Hort.* **2(1-2):** 9-13.

Baskaran, V. and Misra, R. L. 2007. Effect of plant growth regulators on growth and flowering of gladiolus. *Indian J. Hort.* **64(4):** 479-482.

Bhatia, O. S. and Kaur, J. 1997. Effect of homobrassinolide and humicil on chlorophyll content, hill activity and yield components in mung beans (*Vigna radiate* (L) Wilczek). *Phytomorphology*. **47(4):** 421-426.

Chakradhar, M. and Khiratkar, S. D. 2003. Growth and flowering responses of rose cv. Gladiator to certain growth regulant sprays**.** *South Indian Hort.* **51(1-6):** 46-50.

Dahab, A. M., El-dahab, R. S. and Salem, M. A. 1987. Effect of gibberellic acid on growth, flowering and constituents of chrysanthemum. *Acta Hort.* **205:** 129-135.

Dalal, S. R., Somavanshi, A. V. and Karale, G. D. 2009. Effect of gibberellic acid on growth, flowering, yield and quality of gerbera under polyhouse conditions. *International J. Agricultural Sciences.* **5(2):** 355-356.

Delvadia, D. V., Ahlawat, T. R. and Meena, B. J. 2009. Effect of different GA_3 concentration and frequency on growth, flowering and yield in gaillardia (*Gaillardia pulchella* Foug.) cv. Lorenziana. *J. Hortl. Sci.* **4(1):** 81-84.

Dutta, J. P. and Seemanthini, R. 1997. Growth and flowering response of chrysanthemum (*Dendranthema grandiflora* Tzeler) to growth regulators. *The Orissa J. Hort*. **25(2):** 81-86.

Gnyandev, B. 2006. Effect of pinching, plant nutrition and growth retardants on seed yield, quality and storage studies in China aster (*Callistephus chinensis* (L.) Nees.), M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Goszczynska, D. and Rudnicki, R. M. 1988. Storage of cut flowers. *Hort. Rev.* **10:** 35-62.

Goyal, R. K. and Gupta, A. K. 1994. Effect of growth regulators on nutritional status, anthocyanin content and vase life of rose cv. Super star. *Haryana. J. Hort. Sci.* **23(2):** 118-121.

Gupta, V. N. and Datta, S. K. 2001. Influence of gibberellic acid on growth and flowering in chrysanthemum. *Indian J. Plant Physiol.* **6(4):** 420-422.

Haber, A. H. and White, J. D. 1959. Action of maleic hydrazide on dormancy, cell division and cell expansion. *Plant Physiol*. **39:** 459-499.

Halevy, A. H. and Mayak, S. 1979. Senescence and post harvest physiology of cut flowers. Part II. *Hort. Rev*. **1:** 204-236.

Hashemabadi, D. and Zarchini, M. 2010. Yield and quality management of rose (*Rosa hybrida* cv. Poison) with plant growth regulators. *POJ.* **3(6):**167-171.

Jacqmard, A. 1968. Early effects of gibberellic acid on mitotic activity and DNA synthesis in the apical bud of *Rudbeckia bicolor*. *Physiol. Veg.* **6:** 409-416.

Janowska, B. and Andrzejak, R. 2010. Effect of gibberellic acid spraying and soaking of rhizomes on the growth and flowering of calla lily. *Acta Agrobotanica*. **63(2):** 155-160.

Jauhari, O. S. and Amarjit, S. 1960. A note on the effect of maleic hydrazide on growth and flowering of China aster. *Sci. and Cult.* **25:** 697-698.

Kazaz, S. and Karaguzel, O. 2010. Influence of growth regulators on the growth and flowering characteristics of goldenrod (*Solidago x hybrida*). *European J. Scientific Research*. **45(3):** 498-507.

Kliewer, W. M. 1970. Effect of day temperature and light intensity on colouration of grapes (*Vitis vinifera* L.). *J. Amer. Soc. Hort. Sci.* **95:** 693-697.

Loy, J. B. 1977. Hormonal regulation of cell division in the primary elongation of meristems and shoots. In: Mechanisms and control of cell division. T. L. Rost, E. M. Gifford, Dowdedn, Hutchinson Ross and Stroudsburg (Eds), Pennssylvania. pp. 92-110.

Mayoli, R. N., Isutsa, D. K. and Tunya, G. O. 2009. Growth of ranunculus cut flower under tropical high altitude conditions. 1: Effects of GA_3 and shade. *Afr. J. Hort. Sci.* **2:**13-28.

Mittal, S. P. 1967. Studies on the effect of gibberellic acid on growth and flowering of dahlia. *Madras Agric. J.* **54:** 103-107.

Nagarjuna, B., Parathasarathy, R, V., Rama Rao, M. and Nagabushanam Reddy, E. 1988. Effect of growth regulators and potassium nitrate on growth, flowering and yield of chrysanthemum. *South Indian Hort.* **36(3):** 136-140.

Navale, M. U., Aklade, S. A., Desai, J. R. and Nannavare, P. V. 2010. Influence of plant growth regulators on growth, flowering and yield of chrysanthemum (*Dendrathema grandiflora* Tzvelev) cv. 'IIHR-6'. *International J. Pharma and Bio Sciences.* **1(2):** 1-4.

Padmapriya, S. 2000. Effect of gibberellic acid and certain other chemicals on the cut flower production of chrysanthemum (*Dendranthema grandiflora* Tzelev) cultivars, M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Panse, V. G. and Sukhatme, P. V. 1985. Statistical methods for agricultural workers. *Indian Council of Agricultural Research*, New Delhi.

Pappiah, C. M. and Muthuswamy, S. 1978. Effect of growth regulators on growth, flowering, flower quality and essential oil content of *Jasminum auriculatum* var. Parimullai. *South Indian Hort.* **26(2):** 66-71.

Patel, R. B., Parmar, B. R. and Panji, F. G. 2007. Effect of certain chemicals on vase life of rose cv. First Red grown under green house. *The Asian J. Horticulture*. **2(2):** 107-109.

Ramalingam, K. 2008. Effect of growth regulating substances on growth, yield and post harvest quality of cut Rose cv. *Happy Hour, M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.*

Ramdevputra, M. V., Deshmukh, H. N., Butani, A. M., Savaliya, J. J., Pansuriya, A. G. and Kanzaria, D. R. 2009. Effect of different gibberellic acid (GA_3) concentrations on growth, flowering and yield of African marigold. *The Asian J. Horticulture.* **4(1):** 82-85.

Ramesh, K. M. 1999. Effect of certain growth substances and salicylic acid on growth and yield of China aster (*Callistephus chinensis* (L). Nees), M.Sc. (Hort.) Thesis. *Tamil Nadu Agricultural University, Coimbatore.*

Rao, A. V. D. D. 2010. Standardisation of production technology in garland chrysanthemum (*Chrysanthemum coronarium* L.), *Ph. D. (Hort.) Thesis, University of Agricultural Sciences, Dharwad.*

Reddy, Y. T. N. 1997. Effect of growth substances on growth and flowering of China aster (*Callistephus chinensis* (L) Noes.). *Mysore J. Agril. Sci.* **12(3):** 526.

Reddy, Y. T. N. and Sulladmath, U. V. 1983. Influence of growth regulators on flower characters of China aster. *South Indian Hort.* **31:** 252-256.

Sainath. 2009. Influence of spacing, fertilizer and growth regulators on growth, seed yield and quality in annual chrysanthemum (*Chrysanthemum coronarium* L.). *M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.*

Sairam, R. K. 1994. Effects of homobrassinolides application on plant metabolism and grain yield under irrigated and moisture stress conditions of two wheat varieties. *J. Growth Regulation*. **10:** 185-195.

Sen, P. K. and Sen, S. K. 1968. Effect of growth retarding and growth promoting chemicals on growth and flowering of some annuals. *Ind. J. Hort.* **25:** 219-224.

Sharma, C. P., Maurya, A. N., Srivastava, O. P. and Ashok, M. 2001. Role of GA_3, maleic hydrazide and ethrel in modifying vegetative and floral characters of *Chrysanthemum morifolium*. *The Orissa J. Hort.* **29(2):** 35-40.

Singh, B. P. 1966. Influence of gibberellic acid on vegetative growth and flowering of winter annuals. *Sci. and Cult.* **32:** 550-552.

Singh, R. and Rathore, S. V. S. 1992. Effect of different growth regulators on growth, flowering of African marigold (*Tagetes erecta* L.). *Prog. Hort.* **24(1-2):** 92-95.

Sunitha, H. M. 2006. Effect of plant population, nutrition, pinching and growth regulators on plant growth, seed yield and quality of African marigold (*Targetes erecta* L.), M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Yoshida, S., Forno, D. S., Cock, J. H. and Gomez, K. A. 1971. Laboratory manual for physiological studies of rice. *IRRI, Philippines*. pp.1- 43.

Zieslin, N., Biran, I. and Halvey, A. H. 1974. The effect of growth regulators on growth and pigmentation of 'Baccara' rose flowers. *Plant and Cell Physiol*. **75:** 341-349.