INFLUENCE OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD
(Solidago canadensis L.)

BY

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B.Sc. (Agri.)

DEPARTMENT OF HORTICULTURE
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JUNAGADH 362 001

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A STUDY ON THE EFFECT OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD (Solidago canadensis L.)

A THESIS SUBMITTED TO THE JUNAGADH AGRICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

M. SC. (AGRICULTURE)

DEPARTMENT OF HORTICULTURE

COLLEGE OF AGRICULTURE

JUNAGADH AGRICULTURAL UNIVERSITY

JUNAGADH - 362 001

AUGUST - 2006

(REG. No. 24-00000-2004)

Dedicated to my beloved parents and Grandmother.

BY

Vijay
INFLUENCE OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD
(Solidago canadensis L.)

A
THESIS
SUBMITTED TO THE JUNAGADH AGRICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE (AGRICULTURE)

IN
HORTICULTURE

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AUGUST – 2006

(REG. NO. J4-00060-2004)
The present investigation entitled “Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)” was conducted at Horticultural Experimental Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, during July 2005 to November 2005 (first flush) and January 2006 (second flush), was taken from November 2005 to March 2006. The treatments comprised of four different growth regulators viz., GA3 (25, 50 and 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and Picebromacil (250, 500 and 1000 ppm) and Distilled water spray (control). The spray of these treatments was done twice at 30 and 45 days after transplanting. The experiment was laid out in a Randomized Block Design with (Howe) treatments, replicated thrice.

The results revealed that, an application of GA3 100 ppm produced significantly maximum plant height at full bloom stage (125.00 cm), maximum number of nodes per plant (7.86), maximum fresh and dry weight of plant (258.48 and 91.45 g, respectively), lowest number of days taken for first flower initiation (60.06 days), maximum number of inflorescence branches per plant (65.23), longest length of panicle (113.01 cm), number of ears per plant (125.53) and per hectare (5811.10.33).
“Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)”

Name of student                        Major Advisor
Patil Vijay Suresh                     Dr. N. N. Gajipara

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ABSTRACT

The present investigation entitled “Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)” was conducted at Horticultural Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agriculture University, Junagadh, during July 2005 to November 2005 (first flush) and ratoon crop (second flush) was taken from November 2005 to March 2006. The treatments comprised of four different growth regulators viz., GA$_3$ (25, 50 and 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and Paclobutrazol (250, 500 and 1000 ppm) and Distilled water spray (control). The spray of these treatments was done twice at 30 and 45 days after transplanting. The experiment was laid out in a Randomized Block Design with thirteen treatments, replicated thrice.

The results revealed that, an application of GA$_3$ 100 ppm produced significantly maximum plant height at full bloom stage (125.00 cm), maximum number of suckers per plant (7.86), maximum fresh and dry weight of plant (258.48 and 91.45 g, respectively), lowest number of days taken for first flower initiation (60.04 days), maximum number of inflorescence branches per panicle (65.23), longest length of panicle (113.03 cm), maximum diameter of cut flower stalk (6.42 mm), maximum fresh and dry weight of panicles (158.48 and 83.43 g, respectively), maximum yield of panicles per plant (5.23), per plot (125.52) and per hectare (581110.53).
Abstract

The results revealed that, the application of NAA 100 ppm produced significantly maximum plant height at full bloom stage (122.80 cm), maximum number of suckers per plant (7.04), maximum fresh and dry weight of plant (249.74 and 81.88 g, respectively), lowest number of days taken for first flower initiation (60.04 days), maximum number of inflorescence branches per panicle (64.43), longest length of panicle (101.20 cm), maximum diameter of cut flower stalk (4.63 mm), maximum fresh and dry weight of panicles (149.74 and 66.41 g respectively), maximum yield of panicles per plant (4.65), per plot (111.60) and per hectare (516666.15).

Significantly the highest longevity of panicle in situ (17.49 days) and vase life of panicle (7.10 days) was recorded with CCC 500 ppm.

Among the NAA treatments (25, 50 and 100 ppm), 100 ppm NAA recorded best results in vegetative, flowering, yield and quality parameters. Whereas, treatments of CCC (500, 1000 and 2000 ppm) and paclobutrazol (250, 500 and 1000) did not influence on vegetative, flowering and yield attributes.

There was not any residual influence of treatment in the ratoon crop.

Economic point of view, the highest net realization was obtained with GA₃ 100 ppm (236415 Rs. ha⁻¹) followed by NAA 100 ppm (217632 Rs. ha⁻¹), whereas, NAA 100 ppm ranked first with highest C.B.R. (1: 6.35), which was followed by GA₃ 100 ppm (1: 5.37) and NAA 50 ppm (1: 5.00)
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CERTIFICATE – I

This is to certify that Mr. VIJAY SURESH PATIL has successfully completed the comprehensive / preliminary examination held on 17/07/2006 as required under the regulation for post Graduate studies.

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CERTIFICATE - II

This is to certify that the thesis entitled "INFLUENCE OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD (Solidago canadensis L.)" submitted for the degree of MASTER OF SCIENCE (AGRICULTURE) in the subject of HORTICULTURE embodies bonafide research work carried-out by Mr. VIJAY SURESH PATIL under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged.

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Date: 24/11/2006

This is to certify that the thesis entitled "Influence of Growth Regulators on Growth and Flowering of Golden Rod (Solidago canadensis L.)" submitted by Mr. Vijay Suresh Patil to Junagadh Agricultural University, Junagadh in partial fulfillment of the requirements for the degree of Master of Science (Agriculture) in the subject of Horticulture after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination was satisfactory; we therefore, recommend that the thesis be approved.

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Date: 24/11/2006

This is to certify that Mr. VIJAY SURESH PATIL student of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE (Department) has made all corrections / modification in the thesis entitled “INFLUENCE OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD (Solidago canadensis L.)” as suggested by the external examiner and the advisory committee in the oral examination held on 24/11/2006. The final copies of the thesis duly bound and corrected have been submitted on 28 / 11/2006.

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Place : Junagadh
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CERTIFICATE

This is to certify that the thesis entitled, "INFLUENCE OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF GOLDEN ROD (Solidago canadensis L.)" submitted by Mr. PATIL VIJAY SURESH in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE of the JUNAGADH AGRICULTURAL UNIVERSITY is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Junagadh
Date : 24-11/2006

(N. N. Gajipara)
Major Advisor
Emotions can’t be adequately expressed in words hence my acknowledgement is much more than what I am expressing here.

This memorable occasion provides me an unique privilege to express my deep sense of gratitude and indebtedness to my Major Advisor, Dr. N. N. Gajipara, Retired; Head and Professor, Department of Horticulture, J.A.U., Junagadh and his valuable guidance, talented and candid suggestions, constant inspiration and encouragement, keen interest and constructive criticism right from the selection of my research problem up to the final shaping of the thesis in the present form as well as for his keen interest in the preparation of this manuscript.

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I also owe to Dr. P. G. Butani, Principal, College of Agriculture, Junagadh Agricultural University and Dr. D. B. Kuchhadiya, Director of Research and Dean P. G. studies for necessary help to me during the period of study.
I express my heartiest feelings through words to my beloved parents Shri. Suresh M. Patil and Smt. Usha S. Patil without whose moral support, sacrifice and blessings my dream would not have been a reality. Love and encouragement showered by my elder brother Dr. Ajay S. Patil and bhabhi Smt. Sheetal A. Patil, elder sister Dr. Yogita N. Patel and jijaji Dr. Neeraj D. Patel has energized to mount the climax of this exploration.

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Junagadh,

Date: 28/11/2006

(V. S. Patil)
<table>
<thead>
<tr>
<th>Chapter No.</th>
<th>Caption</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>INTRODUCTION</td>
<td>1-5</td>
</tr>
<tr>
<td>II</td>
<td>REVIEW OF LITERATURE</td>
<td>6-47</td>
</tr>
<tr>
<td>III</td>
<td>MATERIALS AND METHODS</td>
<td>48-60</td>
</tr>
<tr>
<td>IV</td>
<td>EXPERIMENTAL RESULTS</td>
<td>61-78</td>
</tr>
<tr>
<td>V</td>
<td>DISCUSSION</td>
<td>79-90</td>
</tr>
<tr>
<td>VI</td>
<td>SUMMARY AND CONCLUSION</td>
<td>91-93</td>
</tr>
<tr>
<td></td>
<td>REFERENCES</td>
<td>I-X</td>
</tr>
<tr>
<td></td>
<td>APPENDIX</td>
<td>i-ii</td>
</tr>
<tr>
<td>Table No.</td>
<td>Caption</td>
<td>Page No.</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.</td>
<td>Meteorological data recorded during the crop season of 2005-2006.</td>
<td>49</td>
</tr>
<tr>
<td>2.</td>
<td>Mechanical and chemical analysis of experimental soil.</td>
<td>51</td>
</tr>
<tr>
<td>3.</td>
<td>Treatments Details</td>
<td>54</td>
</tr>
<tr>
<td>4.</td>
<td>Effect of growth regulators on plant height at full bloom stage.</td>
<td>62</td>
</tr>
<tr>
<td>5.</td>
<td>Effect of growth regulators on number of suckers per plant.</td>
<td>63</td>
</tr>
<tr>
<td>6.</td>
<td>Effect of growth regulators on fresh and dry weight of plant.</td>
<td>65</td>
</tr>
<tr>
<td>7.</td>
<td>Effect on number of days taken for flower initiation.</td>
<td>67</td>
</tr>
<tr>
<td>8.</td>
<td>Effect of growth regulators on length of panicle.</td>
<td>68</td>
</tr>
<tr>
<td>9.</td>
<td>Effect of growth regulators on number of inflorescence branches per panicle</td>
<td>69</td>
</tr>
<tr>
<td>10.</td>
<td>Effect of growth regulators on diameter of cut flower stalk.</td>
<td>71</td>
</tr>
<tr>
<td>11.</td>
<td>Effect of growth regulators on longevity of panicle in situ and vase life of panicle.</td>
<td>73</td>
</tr>
<tr>
<td>12.</td>
<td>Effect of growth regulators on fresh and dry weight of panicle.</td>
<td>74</td>
</tr>
<tr>
<td>13.</td>
<td>Effect of growth regulators on yield of panicles per plant, per plot and per hectare.</td>
<td>76</td>
</tr>
<tr>
<td>14.</td>
<td>Economics of golden rod as influenced by growth regulators.</td>
<td>78</td>
</tr>
<tr>
<td>Figure No.</td>
<td>Caption</td>
<td>After Page No.</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>1.</td>
<td>Lay out plan of experimental site</td>
<td>51</td>
</tr>
<tr>
<td>4.1</td>
<td>Effect of growth regulators on plant height at full bloom stage.</td>
<td>62</td>
</tr>
<tr>
<td>4.2</td>
<td>Effect of growth regulators on number of suckers per plant.</td>
<td>63</td>
</tr>
<tr>
<td>4.3</td>
<td>Effect of growth regulators on fresh and dry weight of plant.</td>
<td>65</td>
</tr>
<tr>
<td>4.4</td>
<td>Effect on number of days taken for flower initiation.</td>
<td>67</td>
</tr>
<tr>
<td>4.5</td>
<td>Effect of growth regulators on length of panicle.</td>
<td>68</td>
</tr>
<tr>
<td>4.6</td>
<td>Effect of growth regulators on number of inflorescence branches per panicle.</td>
<td>69</td>
</tr>
<tr>
<td>4.7</td>
<td>Effect of growth regulators on diameter of cut flower stalk.</td>
<td>71</td>
</tr>
<tr>
<td>4.8</td>
<td>Effect of growth regulators on longevity of panicle <em>in situ</em> and vase life of panicle.</td>
<td>73</td>
</tr>
<tr>
<td>4.9</td>
<td>Effect of growth regulators on fresh and dry weight of panicle.</td>
<td>74</td>
</tr>
<tr>
<td>4.10</td>
<td>Effect of growth regulators on yield of panicle per plant.</td>
<td>76</td>
</tr>
<tr>
<td>4.11</td>
<td>Effect of growth regulators on yield of panicle per hectare.</td>
<td>77</td>
</tr>
</tbody>
</table>
LIST OF PLATES

<table>
<thead>
<tr>
<th>Plate No.</th>
<th>Caption</th>
<th>After page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Golden rod used in decoration.</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Golden rod used in car decoration.</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>General view of experimental area.</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Control (distilled water) on growth and flowering of golden rod</td>
<td>83</td>
</tr>
<tr>
<td>5.</td>
<td>Effect of GA₃ at 100 ppm on growth and flowering of golden rod.</td>
<td>83</td>
</tr>
<tr>
<td>6.</td>
<td>Effect of NAA 100 ppm on growth and flowering of golden rod.</td>
<td>83</td>
</tr>
<tr>
<td>7.</td>
<td>Effect of treatment in vase life.</td>
<td>87</td>
</tr>
</tbody>
</table>

LIST OF APPENDIX

<table>
<thead>
<tr>
<th>Appendix No.</th>
<th>Caption</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cost of cultivation of golden rod required for one hectare.</td>
<td>i</td>
</tr>
<tr>
<td>II</td>
<td>Cost of growth regulators required for one hectare.</td>
<td>ii</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Abbreviations</td>
<td>Meaning</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>1</td>
<td>%</td>
<td>Per cent</td>
</tr>
<tr>
<td>2</td>
<td>/, ^{-1}</td>
<td>Per</td>
</tr>
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<td>@</td>
<td>At the rate</td>
</tr>
<tr>
<td>4</td>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>5</td>
<td>Anon.</td>
<td>Anonymous</td>
</tr>
<tr>
<td>6</td>
<td>CCC</td>
<td>Cycocel [Chlormequat]</td>
</tr>
<tr>
<td>7</td>
<td>C. B. R.</td>
<td>Cost Benefit Ratio</td>
</tr>
<tr>
<td>8</td>
<td>C. D.</td>
<td>Critical difference</td>
</tr>
<tr>
<td>9</td>
<td>C. V.</td>
<td>Co-efficient of variance</td>
</tr>
<tr>
<td>10</td>
<td>cm</td>
<td>Centimeter</td>
</tr>
<tr>
<td>11</td>
<td>cv.</td>
<td>Cultivar</td>
</tr>
<tr>
<td>12</td>
<td>DAT</td>
<td>Days after transplanting</td>
</tr>
<tr>
<td>13</td>
<td>dS</td>
<td>Deci Symonds</td>
</tr>
<tr>
<td>14</td>
<td>E. C.</td>
<td>Electrical conductivity</td>
</tr>
<tr>
<td>15</td>
<td>et al.</td>
<td>Et alii, and others</td>
</tr>
<tr>
<td>16</td>
<td>etc.</td>
<td>Etcetera and rest, So on</td>
</tr>
<tr>
<td>17</td>
<td>Fig.</td>
<td>Figure</td>
</tr>
<tr>
<td>18</td>
<td>FYM</td>
<td>Farm yard manure</td>
</tr>
<tr>
<td>19</td>
<td>g.</td>
<td>Gram</td>
</tr>
<tr>
<td>20</td>
<td>G. A. U.</td>
<td>Gujarat Agricultural University</td>
</tr>
<tr>
<td>21</td>
<td>GA\textsubscript{3}</td>
<td>Gibberellic acid</td>
</tr>
<tr>
<td>22</td>
<td>ha</td>
<td>Hectare</td>
</tr>
<tr>
<td>23</td>
<td>hr.</td>
<td>Hours</td>
</tr>
<tr>
<td>24</td>
<td>i.e.</td>
<td>Id est and that is</td>
</tr>
<tr>
<td>25</td>
<td>J. A. U.</td>
<td>Junagadh Agricultural University</td>
</tr>
<tr>
<td>26</td>
<td>K\textsubscript{2}O</td>
<td>Potassium oxide</td>
</tr>
<tr>
<td>27</td>
<td>kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>28</td>
<td>m</td>
<td>Meter</td>
</tr>
<tr>
<td>29</td>
<td>mm</td>
<td>Millimeter</td>
</tr>
<tr>
<td>30</td>
<td>ml</td>
<td>Milliliter</td>
</tr>
<tr>
<td>31</td>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>32</td>
<td>NAA</td>
<td>Naphthaleneacetic acid</td>
</tr>
<tr>
<td>33</td>
<td>No.</td>
<td>Number</td>
</tr>
<tr>
<td>34</td>
<td>P\textsubscript{2}O\textsubscript{5}</td>
<td>Phosphorus oxide</td>
</tr>
<tr>
<td>35</td>
<td>pH</td>
<td>Potential of hydrogen ion</td>
</tr>
<tr>
<td>36</td>
<td>ppm</td>
<td>Part per million or mg/litre</td>
</tr>
<tr>
<td>37</td>
<td>PP333</td>
<td>Paclobutrazol</td>
</tr>
<tr>
<td>38</td>
<td>RDF</td>
<td>Recommended Dose of Fertilizer</td>
</tr>
<tr>
<td>39</td>
<td>R. H.</td>
<td>Relative humidity</td>
</tr>
<tr>
<td>40</td>
<td>Rs.</td>
<td>Rupees</td>
</tr>
<tr>
<td>41</td>
<td>S. Em.</td>
<td>Standard error of mean</td>
</tr>
<tr>
<td>42</td>
<td>Sq. m</td>
<td>Square meter</td>
</tr>
<tr>
<td>43</td>
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INTRODUCTION

Flowers symbolize beauty, joy, passionate love, feasts, celebrations, tranquility, harmony, peace and divinity. There is a wide reference to flowers in Indian Mythology and Puranas — signifying how important they have been in the country's traditions. Flowers are an inseparable part of human social fabric. Every occasion from birth, to marriage, to death, to any ceremony, whether of rejoicing or sadness is incomplete without flowers. They are used for preparation of garlands, bouquets, marriages, festivals, religious and official ceremonies and for worshipping God. Indian women take great pride in adorning flowers. Also, scented flowers like rose, jasmine, tubers, etc. are used for extracting essential oil which is used in perfumery industries and cosmetics (Joshi, 1994).

India has diverse agro-climatic conditions which permit growing of different varieties of flowers all through the year. Though flower cultivation has been practiced in India since ancient times, horticulture has blossomed into a viable business only in recent years (Mishra et al., 1991). Yet, earlier horticulture in our country was restricted to the growing of traditional flowers such as chrysanthemum, rose, marigold, geranium, jasmine etc., which are used as loose flowers. But today, realizing the importance of cut flowers at national and international levels, cultivation of high value cut flower crops such as nasturtium, carnation, gladiola, golden rod, lilium etc. are also burgeoning popular.

In India, Karnataka, Maharashtra, Andhra Pradesh, West Bengal, Tamil Nadu, Gujarat and Kerala, Madhya Pradesh, Uttar Pradesh, Delhi, Haryana and Kerala are leading states in flower production. The area under flower crops in India is 38,900 ha with a production of 78,096.2 metric tonnes which has been showing a growth rate of 12.8% which is about 460 ha per annum. The total production of 28,470 metric tonnes (Dhank, 2004). Total value of the flower produce is Rs. 500 crore in domestic markets and export with an export worth Rs. 1384.4 crore.
I. INTRODUCTION

Flowers symbolize beauty, purity, passionate love, freshness, surrender, tranquility honesty, peace and divinity. There is a wide reference to flowers in Indian Mythology and Purans – signifying how important they have been in the country’s traditions. Flower is an inseparable part of human social fabric. Every occasion right from birth to marriage till to death, no ceremony whether of rejoicing or sadness is complete without flowers. They are used for preparation of garlands, bouquets, marriages, festivals, religious and official’s ceremonies and for worshiping God. Indian women find great pride in adorning flowers. Also, scented flowers like rose, jasmine, tuberose etc. are used for extracting essential oil, which used in perfumery industries and cosmetics (Laws, 1998).

India has diverse agro-climatic conditions which permit growing of different varieties of flowers all through the year. Though, flower cultivation has been practiced in India since times immemorial, floriculture has blossomed into a viable business only in recent years (Mishra et al., 2001). Yet, earlier floriculture in our country was restricted to the growing of traditional flowers such as chrysanthemum, rose, marigold, gaillardia, jasmine etc., which are used as loose flowers. But today, realizing the importance of cut flowers at national and international levels, cultivation of high value cut flower crops such as rose, gerbera, carnation, gladiolus, golden rod, lilium etc. are also becoming popular.

In India, Karnataka, Maharashtra, Andhra Pradesh, West Bengal, Tamil Nadu, Jammu and Kashmir, Sikkim, Rajasthan, Uttar Pradesh, Delhi, Haryana and Kerala are leading states in flower production. The total area under flower crops in India is 98,000 ha with an estimated production of 5,09,186 metric tonnes which has been showing a continuous increase. In Gujarat nearly 4600 ha land is under floricultural crops with a flower production of 24,420 metric tonnes (Dhaduk, 2004). Total value of the flower produce is Rs. 500 crores in domestic market and fresh cut flowers worth Rs. 127.43 crores
Plate - I: Golden rod used in decoration

Plate - II: Golden rod used in car decoration
are being exported annually from India (Arora and Singh, 2002). World trade in flowers is estimated to be around $50 billion and cut flowers constitute 45 per cent share of the total world trade in floricultural products (Anon., 2003).

Solidago commonly known as “Golden rod” belongs to the family *Asteraceae*. This genus *Solidago* comprises about 130 species. Most of the species are native to North America, a few species are found in South America, Europe and Asia. This herb is promoted and cultivated by Arabs, Italians and Germans as a wound treating herb from ancient times (Patil *et al.*, 1997).

Solidago species like *Solidago canadensis*, *S. virgauria* and *S. memorialis* are commonly grown in beds, borders, rock gardens and also for cut flowers. Besides, they are generally used as cut flowers for indoor decoration as well as in bouquets along with other flowers. Several glycosides and essential oils have also been extracted from the golden rod (Sharma, 1989).

*Solidago canadensis* L. is an erect growing, hardy, perennial plant, grows well in almost all types of climate and soils ranging from light to heavy types of soils. The soil rich in organic matter is ideal for its successful vegetative growth and flowering. It may be sparsely branched or unbranched with simple alternate leaves. It bears panicles of about 90-110 cm in length having 50-60 primary branches. The inflorescence of golden rod is very complex in nature. Basically each small head is about 1.0 to 1.2 cm long with a diameter of about 0.5 to 0.7 cm and consists of about 8-10 disk florets and some ray florets. Heads are axillary, solitary on main axis as well as branches. Such small branches form a whole compound panicle.

The panicles are harvested when about 25 per cent of the flowers had opened and are placed in a container of fresh water. The commercial flower preservatives have been reported to prolong the vase life (Sharma, 1989 and Thube, 2001).

Several hybrids have been evolved from *S. canadensis* and *S. virgaurea*, which have more free flowering and showy flowers. Some of the
cultivars are Ballardi, Golden Gate, Golden Wing, Monte D'oro, Monte Solo, Peter Pan, Straehlen Krone, Super Gold and Tara Gold. Apart from the above, the intergeneric hybrid 'Solidaster' is an excellent cut flower crop (Bhattacharjee and De, 2003).

Golden rod can be planted throughout the year in order to have flower spikes over a wide range of period. It is propagated through division of stools, from suckers or seeds. In moderate climate, suckers or stools are planted throughout the year although spring and rainy seasons are best for good growth. Though, they are gross feeders, soil rich in nutrients promote vegetative growth. Addition of organic manure in the soil is helpful to retain moisture in dry season. When plants become root bound, growth and flowering is reduced, and then the stools are lifted and divided for planting (Bhattacharjee and De, 2003).

Golden rod is an important flower crop at international level, basically as filler material in flower arrangement and bouquets. It has a promising and untapped export potential besides local demand. It serves as background and goes very well with other flowers like rose, gerbera, tuberose, carnation, gladiolus etc. in bouquets and vases. It enriches the beauty of other flowers in vases and bouquets, since it opens its flowers in basipetal manner i.e. from top to bottom, while all others like tuberose, gladiolus open their florets from the base. This way there will be opened flowers in the entire flower arrangement, which enhances the beauty of the whole display. It also provides good support and framework to overall flower arrangement as the stalks are hardy (Patil et al., 1997). Along with low cost of cultivation and hardy nature, it has an additional benefit of providing good support in flower arrangements and bouquets. It is a very good potential flower for dry flower industry. Inspite of very good potential to become an important commercial cut flower in the very near future, not much alternation has been provided towards golden rod.

Plant growth regulators are being effectively used for various purposes in agriculture including horticulture viz., rooting of cuttings,
influencing vegetative and reproductive growth, increased duration of flowering, better quality of products, breaking seed dormancy, better fruit and flower setting and fruit maturity. Growth regulating chemicals improve the physiological efficiency of the plants by regulating the rate of photosynthesis, transpiration, photorespiration, water and nutrient uptake and leaf senescence by imparting resistance of environmental stresses and ultimately increasing the harvest index. It is generally accepted that exogenously applied growth substances produce their effects through the alteration in the levels of naturally occurring hormones, thus modifying the growth and development of plants.

In recent years, scientists have given due attention to the idea of improving the growth, flowering, yield and quality of flower crops with the application of plant growth substances in various ways. Response of flowering plants to growth substances treatments are being increasingly studied with a view of having compact plants with greater number of flowers and also to hasten or delay flowering according to the needs of growers (Yawale et al., 1998).

Gibberellins are the transformation of dwarf plant into tall ones by greatly increased stem elongation (Phinney, 1956). Auxin plays an important role in the cell enlargement of stem and coleoptiles. It also stimulate cell division, initiate flowering and very effective for initiating root formation, it certainly increase the plasticity of the cell wall (Weaver, 1972). Cycocel and Paclobutrazol are very diverse group of compounds and therefore have different biological effects on plants. They generally retarded stem elongation by preventing cell division in the sub apical meristem usually without similarly affecting the apical meristem (Weaver, 1972). These substances modify plant characters like height, number and size of leaves and flowers, branching habit, internodes length, fresh and dry weight and root growth etc. by influencing the physiological process within the plant, which ultimately affects the yield and quality of flowers.
As commercial cultivation of golden rod is comparatively recent one in India, the information available in this aspect is very meager therefore, the present experiment was carried out in field at Horticulture Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during Kharif 2005 on the "Influence of growth regulators (GA_{3}, NAA, CCC and Paclobutrazol) on growth and flowering of golden rod (Solidago canadensis L.)" with the following objectives:

(i) To study the effect of Gibberellic acid (GA_{3}), Napthelene Acetic Acid (NAA), Cycocel (CCC) and Paclobutrazol on vegetative growth of golden rod.

(ii) To study the effect of Gibberellic acid (GA_{3}), Napthelene Acetic Acid (NAA), Cycocel (CCC) and Paclobutrazol on flowering of golden rod.

(iii) To study the effect of Gibberellic acid (GA_{3}), Napthelene Acetic Acid (NAA), Cycocel (CCC) and Paclobutrazol on yield of golden rod.
Review of Literature
As commercial cultivation of golden rod is comparatively recent one in India, the information available in this aspect is very meager. Hence, the information available in closely related crops, *viz.*, chrysanthemum, marigold, china aster, dahlia, carnation, gladiolus, tuberose, gaillardia, gerbera and other ornamental crops has also been reviewed and presented under the following headings.

2.1 EFFECT OF GIBBERELLIC ACID (GA₃)

2.2 EFFECT OF NAPHTHALENE ACETIC ACID (NAA)

2.3 EFFECT OF CYCOCEL (CCC)

2.4 EFFECT OF PACLOBUTRAZOL

2.1 EFFECT OF GIBBERELLIC ACID (GA₃)

A characteristic effect of gibberellic acid on plants is that it makes them taller by causing stem elongation. Rapid stem elongation takes place when rosette plants are sprayed with gibberellic acid. Gibberellins may regulate plant growth via nucleic acid and enzyme synthesis.

The effects of GA₃ on growth parameters in different flowering plants have been reported by several workers are being reviewed under the following sub heads.

2.1.1 Vegetative Growth Attributes

Growth is a permanent and irreversible increase in size and volume of the plant with an accompanied increase in dry weight (Verma, 1991). It is due to the formation of new cells at localized region called meristem and increase in size and mass of cell produced.
2.1.1.1 Plant height at full bloom stage. (cm)

Plant height is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing plant height of golden rod and some other flowering crops is being reviewed as below.

Golden rod

Patil et al., (1996) conducted an experiment on effect of growth regulators on golden rod. Their investigation revealed that, GA₃ increased the plant height to a considerable extent.

Pavagadhi (2001) reported that GA₃ at 150 ppm significantly gave maximum plant height (64.67 cm).

Borse (2005) observed that maximum plant height was recorded with GA₃ 200 ppm (145.13 cm).

Chrysanthemum

Dutta et al., (1993, 1995 and 1998) reported that, an increase in plant height with the application of GA₃ at 150 ppm in cv.'Co-1'.

Rajagopalan and Khader (1994) observed that, GA₃ at 100 and 200 ppm gave maximum plant height in case of Co-1 and Co-2 cultivars, where spray was done at 30 and 45 days after transplanting.

Talukdar and Paswan (1994) observed that, all the GA₃ treatments (10, 20 and 40 ppm) increased the plant height significantly over the control in cv. 'Tumruli'.

Talukdar and Paswan (1996) also observed that, GA₃ 40 ppm significantly increased the plant height over control in cv. 'Prof. Harris'.

Talukdar and Paswan (1997) found that, all the GA₃ treatments (10, 20 and 40 ppm) increased the plant height significantly over control in cv. 'Maharaja'. 
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Talukdar and Paswan (1998) reported that, an application of GA$_3$ 40 ppm significantly increased the plant height in all the four cultivars of chrysanthemum viz., 'Snow Ball', 'Kiku Biori', 'Grape Bowl' and 'Lilac'.

Kumar and Ugherja (1998) revealed that, GA$_3$ at all levels (50, 100 and 150 ppm) increased plant height of cv. 'IIHR-6'.

Meher et al., (1999) observed that, GA$_3$ 150 ppm increased the plant height over control.

Rakesh et al., (2003) observed that, plant height increased with the increase in concentration of GA$_3$ ranging from 50 to 200 ppm and all the treatments of GA$_3$ (50, 100, 150 and 200 ppm) significantly increased the plant height over control in both the cultivars 'Flirt' and 'Gauri'.

**Marigold**

Singh et al., (1991) observed linear increase in the plant height with GA$_3$ 100-500 ppm concentrations. However, GA$_3$ 500 ppm was found most effective in increasing the plant height.

Pandya (2000) reported that, significantly maximum plant height was found at GA$_3$ 150 ppm followed by GA$_3$ 100 ppm in cv. 'Lemon Yellow'.

**China aster**

Kumar (1998) reported increased plant height at all the concentrations (100, 150 and 200 ppm) of GA$_3$, but maximum height was observed at GA$_3$ 200 ppm in cv. 'Ostrich Plume Mixed'.

Kumar, et al., (2003) studied the effect of GA$_3$ on growth and yield of china aster, which treated with three concentrations of GA$_3$, i.e. 50 ppm, 100 ppm, 200 ppm and a control and concluded that, in all the treatments, 200 ppm, GA$_3$ was best in most of the characters of china aster.
Gaillardia
Makwana (1999) found significant increase in plant height at 100 and 150 ppm GA₃ when sprayed on gaillardia. However, maximum plant height was found at 150 ppm of GA₃.

Gladiolus
Ravidas et al., (1992) reported that, an application of GA₃ 100 ppm significantly increased the plant height in cv. 'Friendship'.

Misra et al., (1993) studied the effect of foliar application (53 days of planting at 4 leaves stage) of gibberellic acid (0, 50, 100, 200 and 400 ppm) on cv. 'Sylvia' and observed that, the plant height was significantly more at 100 and 200 ppm GA₃.

Ved and Jha (1998) reported that, spraying of GA₃ with 100 ppm and 150 ppm significantly increased the plant height as compared to control in cv. 'Friendship'.

Maurya and Nagda (2002) observed maximum plant height with GA₃ at 100 ppm in cv. 'Friendship'.

Tuberose
Nagaraja et al., (1999) observed that, an application of GA₃ at 500 ppm and 1000 ppm spray increased plant height in cv. ‘Single’.

2.1.1.2 Number of suckers per plant at harvesting
Number of suckers per plant is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing the number of suckers per plant of golden rod and other flowering crops is being reviewed below.

Golden rod
Patil et al., (1996) conducted an experiment on effect of growth regulators in golden rod and their investigation revealed that, GA₃ increased the number of suckers per plant to a considerable extent.
Pavagadhi (2001) obtained maximum number of sucker per plant (6.87) when golden rod was sprayed with GA₃ at 150 ppm as compared to control (3.60).

Borse (2005) reported that, the highest number of suckers per plant was obtained with GA₃ 200 ppm (7.23) as compared to control (4.20).

**Gerbera**

Nair *et al.*, (2002) recorded maximum number of suckers per plant when plants, were sprayed with 100 ppm GA₃ followed by 50 ppm GA₃, which was found at par with 150 ppm GA₃.

**Gladiolus**

Ravidas *et al.*, (1992) noticed maximum number of cormels per plant with GA₃ 100 ppm in cv. 'Friendship'.

Misra *et al.*, (1993) observed maximum number of cormels per plant with GA₃ 400 ppm in cv. 'Sylvia'.

Nazki and Arora (2000) found in cv. 'Sancerve', GA₃ treatments did not increase the number of cormals per cormal as compared to control in gladiolus.

**Tuberose**

Nagaraja *et al.*, (1999) reported that, all the GA₃ treatments increased number of bulbs in cv. 'Single'.

Singh (1999) observed significantly more number of bulbs with 100 and 200 ppm GA₃.

Singh *et al.*, (2003) reported that, spraying of GA₃ 100 ppm increased number of bulbs per plant significantly over control.

2.1.1.3 **Fresh and dry weight of plant (g)**

Weight of plant is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work
done on use of PGRs in influencing fresh and dry weight of golden rod and other flowering crops is being reviewed below.

**Golden rod**

Patil *et al.*, (1996) conducted an experiment on effect of growth regulators in golden rod and their investigation revealed that, GA$_3$ increased the number of suckers per plant to a considerable extent.

Pavagadhi (2001) reported that, spraying of GA$_3$ 150 ppm significantly increased fresh weight of plant (83.63g) and dry weight of plant (26.37g) over control (49.35g and 17.53g, respectively).

Borse (2005) reported that, maximum fresh and dry weights of plants were obtained with GA$_3$ 200 ppm (243.47 and 90.78 g, respectively) as compared to control (211.24 g and 64.89 g, respectively).

**Tuberose**

Dalal *et al.*, (1999) reported that, increasing the flower weight (106.14 g/plant) as compared to the control when sprayed with 40 ppm GA$_3$ in tuberose (*Polianthus tuberosa* L.).

Singh *et al*. (2003) conducted experiment on the response of plant growth regulators on tuberose (*Polianthus tuberosa* L.) cv. Double and observed that, GA$_3$ at 100 ppm (spraying) increased the weight (90.52 g) of tuberose.

2.1.2 **Flowering Attributes**

The change of meristem from the vegetative to the reproductive stage is one of the most important events in the life of plant. This process is called as flowering.

The first attempt at general explanation of the flowering was on the basis of the carbohydrate-nitrogen ratio (Kraus and Kragbill, 1918). Gibberellins have been shown to induce flowering in several plant species. Different plant species report differently to different gibberellins. An
application of GA3 induces the majority of long day and cold requiring plants to flower. In some plants an increase flowering may be associated with elongation of internodes. In gibberellins treated plants, flower size increase due to the increase in the size of petals.

The effect of GA3 on flowering attributes in golden rod and other flowering plants have been reported by several workers are being reviewed as below.

2.1.2.1 Number of days taken for flower initiation

Number of days taken for flower initiation is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing number of days taken for flowering initiation of golden rod and other flowering crops are being reviewed below.

Golden rod

Patil et al., (1996) revealed that, all the concentrations of GA3 (50, 100 and 200 ppm) takes shortest period for first flowering.

Pavagadhi (2001) found that, all the concentrations of GA3 (50, 100 and 150 ppm) significantly increased number of days taken for flower initiation. GA3 150 ppm taken less number of days for flower initiation as compared to control.

Borse (2005) the minimum number of days taken for 50 per cent flowering (117.31 days) and early flowering days (88.87) was found at GA3 200 ppm.

Chrysanthemum

Dutta et al., (1993) reported earliness in commencement of flowering with GA3 in both the years in cv. 'Co-1'.
Rajagopalan and Khader (1994) reported that, cultivars 'Co-1' and 'Co-2' sprayed with 100 ppm of GA₃ flowered earlier.

Poshiya et al., (1995a) observed that, GA₃ 250 ppm requires less number of days to flowering as compared to control in cv. 'Mayur'.

Dutta et al., (1998) found that, all the concentrations of GA₃ (50, 100 and 150 ppm) significantly increased flowering in both the years.

Meher et al., (1999b) reported that, the number of days taken for first flowering was significantly earlier when plants were sprayed with GA₃ 100 and 150 ppm as compared to control.

**Marigold**

Singh et al., (1991) reported that, GA₃ (100-150 ppm) hastened flowering in African marigold.

**Gaillardia**

Poshiya et al., (1995a) revealed that, GA₃ treatments (200, 500 and 750 ppm) significantly advanced the commencement of flowering over control in cv. 'Yellow Giant'.

**Gerbera**

Nair et al., (2002) observed that, minimum days required to first flowering with an application of GA₃ (50, 100 and 150 ppm).

**Gladiolus**

Misra et al., (1993) observed that, the first flower opening was significantly delayed (113.5 days) under 400 ppm GA₃ as compared to control (110.7 days) in cv. 'Sylvia'.

Ved and Jha (1998) recommended that, GA₃ 150 ppm followed by 100 ppm increased earlier flowering as compared with control in cv. 'Friendship'.

Maurya and Nagda (2002) observed that, all concentrations (50 and 100 ppm) of GA₃ minimize the days require to first flowering in cv. 'Friendship'.


**Tuberose**

Nagaraja *et al.*, (1999) reported the earlier flowering with GA$_3$ at 500 and 1500 ppm as compared to control in cv. 'Single'.

Singh (1999) reported that, GA$_3$ at 100 and 125 ppm required less number of days to flowering as compared to control.

### 2.1.2.2 Effect on length of panicle (cm)

Length of panicle is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing length of panicles of golden rod and other flowering crops is being reviewed below.

**Golden rod**

Patil *et al.*, (1996) reported that, all the concentrations of GA$_3$ (50, 100 and 200 ppm) produced longest flower stalk as compared to control.

Pavagadhi (2001) reported that, higher concentration of GA$_3$ (150 ppm) resulted in significantly maximum length of panicles (108.13 cm) as compared to the control (103.87 cm).

Borse (2005) reported that, the maximum length of panicle was found at GA$_3$ 200 ppm (110.40 cm) as compared to control (94.42 cm).

**Chrysanthemum**

Dutta *et al.*, (1993) observed, maximum length of flower stalk with all the concentrations of GA$_3$ (50, 100 and 150 ppm) in cv. 'Co-1'. Likewise, Dutta *et al.*, (1995) also observed maximum length of flower stalk with 100 and 150 ppm GA$_3$. Poshiya *et al.*, (1995b) observed maximum pedicle length when plants were sprayed with GA$_3$ 250 ppm in cv. 'Mayur'. Similarly, Kumar and Ugherja (1998) found that, an application of GA$_3$ 100 and 150 ppm increased peduncle length in cv. 'IIHR-6'.
Meher et al., (1999) application of GA₃ 150 ppm was found optimum for obtaining higher length of internode and stem length.

**Gaillardia**

Poshiya et al., (1995a) observed that, when plant sprayed with GA₃ at 250 ppm gave maximum stalk length in cv. 'Yellow Giant'.

**Gladiolus**

Ravidas et al., (1992) found that, an application of GA₃ at all the concentrations (50 and 100 ppm) produced longest spike in cv. 'Friendship'.

Misra et al., (1993) reported that, all the treatments of GA₃ (50, 100, 200, and 400 ppm) significantly increased the length of spike in the ascending order of the treatments in cv. 'Sylvia'.

Karaguzel et al., (1999) observed increased length of flower stems when sprayed with foliar application of GA₃ at 100 ppm in gladiolus (Goladiolus grandiflorus) cv. 'Eurovision'.

Maurya and Nagda (2002) noticed maximum spike length with GA₃ at 50 and 100 ppm in cv. 'Friendship'.

**Tuberose**

Nagaraja et al., (1999) reported that, GA₃ at 500 and 1000 ppm increased length of flower spike and rachis length in cv. 'Single'.

Singh (1999) reported that, GA₃ at 100 and 200 ppm produced longest spike. Similarly, Singh et al. (2003) observed maximum length of spike with GA₃ 50 and 100 ppm.

**Gerbera**

Nair et al., (2002) reported that, maximum length of flower stalk was produced with GA₃ 150 ppm followed by GA₃ 100 and 50 ppm.
2.1.2.3 Number of inflorescence branches per panicle

Number of inflorescence branches per panicle is considered as one of the important attributes for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing number of inflorescence branches per panicle of golden rod and other flowering crops is being reviewed below.

**Golden rod**

Patil *et al.*, (1996) reported that, significantly highest numbers of spikelets per flower stalk were produced with all the concentrations of GA$_3$ (50, 100 and 200 ppm).

Pavagadhi (2001) found that, GA$_3$ 150 ppm significantly increased higher number of inflorescence branches per panicle (60.00 branches) as compared to control.

Borse (2005) reported that, the highest number of inflorescence branches per panicle was obtained at GA$_3$ 200 ppm (58.40) as compared to control (48.18).

**Chrysanthemum**

Rajagopalan and Abdul Khader (1994) obtained that, GA$_3$ at 200 ppm increased the number of branches and internodes length in both ‘Co-1’ and ‘Co-2’ varieties of *C. indicum*.

Dutta *et al.*, (1998) observed GA$_3$ (50, 100 and 150 ppm) significantly increased the number of laterals per plant as compared with control in chrysanthemum.

Meher *et al.*, (1999) reported that, the growth regulator treatment with GA$_3$ 150 ppm recorded maximum number of branches in chrysanthemum, when it was significantly superior to June and July planting.

**Gladiolus**

Ravidas *et al.*, (1992) observed that, GA$_3$ at 50 and 100 ppm produced maximum number of florets per spike in cv. 'Friendship'.
Maurya and Nagda (2002) reported that, GA₃ 100 ppm produced maximum number of florets per spike in cv. 'Friendship'.

**Tuberose**

Nagaraja *et al.* (1999) reported that, the florets per spike was enhanced by GA₃ 500 ppm and 1500 ppm in cv. 'Single'.

Singh (1999) observed that, spraying of GA₃ at 200 ppm markedly increased number of florets per spike in tuberose.

**2.1.2.4 Diameter of cut flower stalk (mm)**

Diameter of cut flower stalk played as one of the important role for the study of cultural practices of any kind of flower crops. Therefore, work done on use of PGRs in influencing diameter of cut flower stalks of golden rod and other flowering crops is being reviewed below.

**Golden rod**

Patil *et al.* (1996) reported that, all the concentrations of GA₃ (50, 100 and 200 ppm) produced highest diameter of cut flower stalk as compared to control.

Pavagadhi (2001) reported that, the largest flower size in terms of diameter with longest flower stalk was registered with GA₃ 150 ppm.

**Chrysanthemum**

Meher *et al.* (1999) reported that, the flowering diameter was increased (7.14 cm) with 150 ppm GA₃ in chrysanthemum.

**Gladiolus**

Karaguzel *et al.* (1999) recommended the application of GA₃ 100 ppm at the 3 to 4 stages of leaves in *Gladiolus grandiflorus* cv. 'Eurovision' for increased diameter of flower stems.

**Tuberose**

Devendra and Nagda (1999) studied the effect of foliar application of 200 ppm of GA₃ and found significant increase in flower
diameter (3.67) compared to the other treatments and the control in tuberose
(Polianthus tuberosa L.) cv. ‘Single’.

2.1.2.5 Longevity of inflorescence in situ (days)
Golden rod
Pavagadhi (2001) reported that, higher concentration of GA₃ at
150 ppm resulted in significantly maximum longevity of inflorescence in situ.
Borse (2005) observed maximum longevity of golden rod flowers
with GA₃ at 200 ppm treatment.

Chrysanthemum
Kumar and Ugherja (1998) observed maximum longevity of
chrysanthemum flowers with GA₃ 100 and 150 ppm in cv. 'IIHR-6'.

Gladiolus
Misra et al., (1993) observed that, durability of whole spike of cv.
'Sylvia' was increased with the increase in the GA₃ levels (50, 100, 200, and
400 ppm).

2.1.2.6 Fresh weight of panicle (g)
Golden rod
Pavagadhi (2001) observed highest fresh weight of panicle at
GA₃ 150 ppm in Golden rod.

Chrysanthemum
Mohandas (1986) observed higher fresh weight of flowers at 25
ppm GA₃ as compared to control.
Nagarjuna et al., (1988) recorded an increase in fresh weight of
flowers with GA₃ treatments (100 and 200 ppm).
Talukdar and Paswan (1994) reported that, GA3 at 20 ppm significantly increased the fresh weight of flowers in cv. 'Tumruli'. Same scientists in (1996) observed that, all the treatments of GA3 (10, 20 and 40 ppm) significantly increased the fresh weight of flowers in cv. 'Prof. Harris'.

2.1.2.7 Dry weight of panicle (g)

Golden rod

Pavagadhi (2001) observed highest dry weight of panicle at 150 ppm GA3 treatment in golden rod.

Chrysanthemum

Mohandas (1986) observed higher dry weight of flowers at 25 ppm GA3 as compared to control. Likewise, Talukdar and Paswan (1994) reported that, 20 ppm GA3 significantly increased the dry weight of flowers in cv. 'Tumruli'.

Talukdar and Paswan (1996) observed that, all the treatments of GA3 (10, 20 and 40 ppm) significantly increased the dry weight of flowers in cv. 'Prof. Harris'.

2.1.2.8 Number of panicles per plant

Golden rod

Pavagadhi (2001) reported that, significantly maximum numbers of panicles/ plant were resulted the application of higher concentration of GA3 (150 ppm).

Borse (2005) reported that, the highest number of panicles per plant was obtained with 200 ppm GA3.

Chrysanthemum

Dutta et al., (1993) noted that, GA3 treatments ranked first in increasing the number of flowers. The highest flower yield by number was obtained with 150 ppm GA3 in cv. 'Co-1'.

19
According to Rajgopalan and Khader (1994), GA$_3$ 100 and 200 ppm gave the highest number of flowers per plant in case of 'Co-1' and 'Co-2' cultivars, when sprayed 30 and 40 days after planting.

Talukdar and Paswan (1994) found that, GA$_3$ 10 and 20 ppm increased the number of flowers per plant significantly over the control in cv. 'Tumruli'.

Dutta et al. (1995) observed significantly maximum number of flowers per plant with GA$_3$ 150 ppm.

Poshiya et al. (1995a) recorded highest number of flowers with 100 ppm GA$_3$ in cv. 'Mayur'.

Talukdar and Paswan (1997) reported that, GA$_3$ (10, 20 and 40 ppm) produced significantly higher number of flowers per plant in cv. 'Maharaja'.

Kumar and Ugherja (1998) reported that, significantly maximum number of flowers per plant with GA$_3$ 150 ppm followed by GA$_3$ 100 ppm in chrysanthemum cv. 'IIHR-6'.

**Marigold**

Singh et al. (1991) observed that, GA$_3$ 500 ppm recorded the highest number of flowers per plant and with increase in the concentration of GA$_3$ from 100 ppm to 500 ppm there was a progressive increase in the number of flower per plant.

Pandya (2000) reported that, significantly maximum number of flowers per plant with GA (50, 100 and 150 ppm) in cv. 'Lemon Yellow'.

**Gladiolus**

Maurya and Nagda (2002) noticed highest number of spikes per pant with GA$_3$ 100 ppm in cv. 'Friendship'.


2.1.2.9 Yield of panicle per plot per ha.

Golden rod

Pavagadhi (2001) reported that, significantly maximum numbers of panicles per plot and per hectare were resulted from the application of higher concentration of GA₃ (150 ppm).

Borse (2005) reported that, the highest yield (number of panicles) per plant, per plot and per hectare was obtained with GA₃ 200 ppm.

Chrysanthemum

Dutta et al., (1993) highest flower yield by number and by weight, obtained from the plants sprayed with GA₃ at 150 ppm in the first and second years. This was followed closely by GA₃ 100 and GA₃ 50 ppm. In another study, they (1998) observed that, the cut flower yield was highest with 100 ppm GA₃ treatment in cv. 'Co-1'.

Poshiya (1995b) observed maximum flower yield with GA₃ 100 ppm in cv. 'Mayur'. Likewise, Kumar and Ugherja (1998) observed significantly highest flower yield with all the treatments of GA₃ (50, 100 and 150 ppm) in cv. 'IIHR-6'.

Meher et al., (1999) reported that, the highest flower yield was obtained when plants were sprayed with 50 ppm GA₃ in May planting.

Rakesh et al., (2003) highest flower yield was recorded with GA₃ at 100, 150 and 200 ppm in 'Flirt' and 'Gauri' cultivars.

Marigold

Singh et al., (1991) reported that, GA₃ at 400 and 500 ppm gives significantly higher yield.

Pandya (2000) recorded significantly highest flower yield with all treatments of GA₃ (50, 100 and 150 ppm) in cv. 'Lemon Yellow'.


Gaillardia

Poshiya et al., (1995a) observed that, significantly highest flower yield was obtained with 250 and 500 ppm in gaillardia.

Makwana (1999) reported that, an application of GA$_3$ at 50, 100 and 150 ppm gives maximum flower yield in cv. 'Lorenziana'.

2.1.2.10 Vase life of panicle (days)

Golden rod

Patil et al., (1996) reported that, vase life of golden rod flower stalk was obtained higher with GA$_3$ (50, 100 and 200 ppm) treated plants.

Patil et al., (1997) reported that, GA$_3$ 100 ppm resulted in the significant increase in the vase life (5 to 7 days) in golden rod (*Solidago canadensis* L.)

Philosoph et al., (1997) recommended GA$_3$ for retarding early leaf yellowing in flowering shoots of golden rod (*Solidago canadensis* L.)

Pavagadhi (2001) reported that, higher concentration of GA$_3$ (150 ppm) produced flowers with the longest shelf life (8.55 days) as compared to control (6.44 days).

Borse (2005) noted that, the GA$_3$ at the 200 and 150 ppm takes significantly more days of keeping quality of panicles as compared to control.

Chrysanthemum

Dutta et al., (1993) found that, vase life increased with subsequent increase in concentrations of GA$_3$ (50, 100 and 150 ppm) in cv. 'Co-1' during two successive season.

Talukdar and Paswan (1997) revealed that, GA$_3$ at 10 ppm significantly increased the vase life of flowers in cv. 'Maharaja'.
Marigold
Pandya (2000) reported that, GA₃ at (50, 100 and 150 ppm) significantly increased the vase life of flowers over control in cv. 'Lemon Yellow'.

China aster
Kumar (1998) found that, GA₃ promoted the vase life of flowers when treated with 100, 150 and 200 ppm concentrations.

Gaillardia
Makwana (1999) found that, GA₃ treatments (50, 100 and 150 ppm) increased the vase life of flowers at various concentrations as compared to control.

2.2 EFFECT OF NAPHTHALENE ACETIC ACID (NAA)
Naphthalene acetic acid is a synthetic auxin, most widely used as practical growth substances. In general, NAA promotes vegetative growth, delay flowering, increase flower size etc. The mode of action of NAA depends on concentration used. The response of NAA on plant growth and flowering of some flowering crops are reviewed as below.

2.2.1 Vegetative Growth Attributes
As far as auxins are concerned, the increase in linear growth of stem is due to cell elongation. The increase in size occurs in two stages. First at the process that requires the presence of auxin and oxygen which cause loosening off of the cell wall and the second is by an uptake of water and an expansion of the wall.
2.2.1.1 Plant height at full bloom stage (cm)

Golden rod

Pavagadhi (2001) found that, NAA (100 ppm) increased plant height as compared to control in golden rod.

Borse (2005) noted that, NAA (100 and 150 ppm) significantly increased plant height as compared to control.

Chrysanthemum

Sharma et al., (1995) recommended spraying of 25 ppm NAA one month after transplanting for increasing the plant height of cv. 'Move-in-Carvin'. There was positive correlation between concentration of NAA and plant height.

Dutta et al., (1998) recommended that, spraying of NAA at 50 ppm increased the plant height as compared with control, but plant height decreased when concentration of NAA was increase.

Kumar and Ugherja (1998) found that, plants treated with NAA at all the concentrations (25, 75 and 125 ppm) showed an increase of plant height as compared to control in cv. 'IIHR-6'.

Marigold

Singh and Rathore (1992) studied that, when different NAA concentrations (25, 50 and 100 ppm) were sprayed on African marigold, there was reduction in plant height except in 25 ppm NAA.

Pandya (2000) observed that, all the NAA treatments (100, 200 and 300 ppm) significantly increased the plant height over control in cv. 'Lemon Yellow'.

Gladiolus

Ravidas et al., (1992) observed the reduction in plant height of cv. 'Friendship' at 100 and 200 ppm of NAA. On the other hand, Maurya and Nagda (2002) reported that, 50 and 100 ppm of NAA increased plant height as compared to control in cv. 'Friendship'.
2.2.1.1 Plant height at full bloom stage (cm)

Golden rod

Pavagadhi (2001) found that, NAA (100 ppm) increased plant height as compared to control in goldenrod.

Borse (2005) noted that, NAA (100 and 150 ppm) significantly increased plant height as compared to control.

Chrysanthemum

Sharma et al., (1995) recommended spraying of 25 ppm NAA one month after transplanting for increasing the plant height of cv. 'Move-in-Carvin'. There was positive correlation between concentration of NAA and plant height.

Dutta et al., (1998) recommended that, spraying of NAA at 50 ppm increased the plant height as compared with control, but plant height decreased when concentration of NAA was increase.

Kumar and Ughterja (1998) found that, plants treated with NAA at all the concentrations (25, 75 and 125 ppm) showed an increase of plant height as compared to control in cv. 'IIHR-6'.

Marigold

Singh and Rathore (1992) studied that, when different NAA concentrations (25, 50 and 100 ppm) were sprayed on African marigold, there was reduction in plant height except in 25 ppm NAA.

Pandya (2000) observed that, all the NAA treatments (100, 200 and 300 ppm) significantly increased the plant height over control in cv. 'Lemon Yellow'.

Gladiolus

Ravidas et al., (1992) observed the reduction in plant height of cv. 'Friendship' at 100 and 200 ppm of NAA. On the other hand, Maurya and Nagda (2002) reported that, 50 and 100 ppm of NAA increased plant height as compared to control in cv. 'Friendship'.

24
2.2.1.2 Number of suckers per plant at harvesting

Golden Rod

Pavagadhi (2001) found that, NAA (125 ppm) increased number of suckers per plant as compared to control in golden rod.

Borse (2005) noted that, NAA (150 ppm) significantly increased number of suckers per plant as compared to control.

Gladiolus

Ravidas et al., (1992) noticed more number of cormels over control with all treatments of NAA (100 and 200 ppm) in cv. 'Friendship'.

Tuberose

Singh et al., (2003) observed significantly more number of bulbs and bulblets per plant over control with NAA 50 ppm.

2.2.1.3 Fresh and dry weight of plant (g)

Golden Rod

Pavagadhi (2001) found that, NAA (125 ppm) increased fresh and dry weight of plants as compared to control in golden rod.

Borse (2005) reported that, NAA (100 ppm) significantly increased fresh and dry weight of plant as compared to control.

Chrysanthemum

Poshiya et al., (1995b) reported that, fresh weight of individual flower in cv. 'Mayur' was not significantly affected by any treatment of NAA at varied levels i.e. 15, 30, 45 and 60 ppm.
2.2.2 Flowering Attributes

2.2.2.1 Number of days taken for flower initiation

Golden Rod

Pavagadhi (2001) found that, plants treated with NAA at 125 ppm took the minimum number of days for initiation of panicle over control in golden rod.

Borse (2005) observed that, number of days taken for first flower initiation in golden rod was not significantly affected by any treatment of NAA at varied levels i.e. 50, 100 and 150 ppm.

Chrysanthemum

Dutta et al., (1993) reported that, an earliness in commencement of flowering over control was significantly observed with NAA (50, 75 and 100 ppm) in both the years in cv. 'Co-1'.

Poshiya et al. (1995b) observed that, all the levels of NAA (15, 30, 45 and 60 ppm) significantly produced early flower formation by 5-7 days as compared to control in cv. 'Mayur'.

Dutta et al., (1998) studied that, all the concentration of NAA (50, 75 and 100 ppm) significantly delayed flowering in both the years.

Gaillardia

Poshiya et al., (1995a) reported that, all the levels of NAA (15, 30 and 45 ppm) initiate early flowering and NAA 15 ppm was found most effective as compared to other treatments in cv. 'Yellow Giant'.

Gladiolus

Ravidas et al., (1992) reported that, NAA at 100 and 200 ppm delayed flowering over control in cv. 'Friendship'.

Maurya and Nagda (2002) revealed that, all the NAA treatments significantly reduced the average number of days to first flowering as compared to control in cv. 'Friendship'.

Effect on length of panicle (cm)

Golden rod

Pavagadhi (2001) reported that, the maximum length of panicle was recorded at NAA 125 ppm as compared to control in golden rod.

Borse (2005) observed that, length of panicle in golden rod was not significantly affected by any treatment of NAA at varied levels i.e. 50, 100 and 150 ppm.

Chrysanthemum

Dutta et al., (1993) observed that, spraying of NAA 50, 75 and 100 ppm significantly increased the length of the stalk over the control in cv. 'Co-1'.

Dutta et al., (1995) reported that, spraying of NAA 50, 75 and 100 ppm increased the length of the stalk as compared to control.

Poshiya et al., (1995a) observed highest pedicle length when plants were sprayed with NAA 45 ppm in cv. 'Mayur'.

Kumar and Ugherja (1998) found that, an application of NAA at 25 and 75 and 125 ppm increased peduncle length as compared to control in cv. 'IIHR-6'.

Gaillardia

Poshiya et al., (1995a) observed highest pedicel length when plants were sprayed with NAA 15 and 30 ppm in cv. 'Yellow Giant'.

Gladiolus

Ravidas et al., (1992) found that, an application of NAA 100 and 200 ppm reduced length of spike as compared to control in cv. 'Friendship'.

Maurya and Nagda (2002) noticed maximum spike length with NAA 50 ppm followed by NAA 100 ppm over control in cv. 'Friendship'.

Tuberose

Singh et al., (2003) noticed no significant difference in length of spike with spraying of NAA (50 and 100 ppm) as compared with control.
2.2.2.3 Number of inflorescence branches per panicle

Golden rod

Pavagadhi (2001) found that, NAA (125 ppm) increased number of inflorescence branches per panicle as compared to control in golden rod.

Borse (2005) observed that, number of inflorescence branches per panicle in golden rod was not significantly affected by any treatment of NAA at varied levels i.e. 50, 100 and 150 ppm.

Gladiolus

Ravidas et al., (1992) observed that, 100 and 200 ppm levels of NAA produced more number of florets per spike in cv. 'Friendship'.

Maurya and Nagda (2002) reported that, both the treatments of NAA (50 and 100 ppm) produced more number of florets per spike in cv. 'Friendship'.

2.2.2.4 Diameter of cut flower stalk (mm)

Golden rod

Pavagadhi (2001) reported that, maximum diameter of cut flower stalk was obtained with NAA 125 ppm as compared to control in golden rod.

China aster

Reddy and Sulladmath (1983) reported that, the NAA 30 ppm and 60 ppm increased the diameter of the peduncle in china aster (Callistephus chinensis L. Ness) ‘Powder Puff Mixed’ as compared with control.

Marigold

Singh and Rathore (1992) reported that, the higher concentration of NAA (100 ppm) reduced the plant girth in African marigold (Tagetes erecta L.).
2.2.2.5 Longevity of inflorescence *in situ* (days)

**Golden rod**

Pavagadhi (2001) reported that, highest longevity of panicles *in situ* was obtained at NAA 125 ppm as compared to control in golden rod. Borse (2005) reported that, slightly increased longevity of inflorescence was recorded at NAA 150 ppm over control in golden rod.

**Chrysanthemum**

Kumar and Ugherja (1998) observed that, longevity of flowers was more over control at all levels of NAA (25, 75 and 125 ppm) in cv. 'IIHR-6'.

**Gladiolus**

Maurya and Nagda (2002) revealed that, the more longevity of florets on spike was recorded under NAA at 50 ppm as compared to control in cv. 'Friendship'.

**Tuberose**

Singh and Kumar (2003) found reduction in longevity of whole spike at all concentrations of NAA (50 and 100 ppm).

2.2.2.6 Fresh weight of panicle

**Golden rod**


**Chrysanthemum**

Poshiya *et al.*, (1995a) reported that, fresh weight of individual flower in cv. 'Mayur', was not significantly affected by any treatment of NAA at varied levels i.e. 15, 30, 45 and 60 ppm.
2.2.2.7 Dry weight of panicle

Golden rod

Pavagadhi (2001) reported that, highest dry weight of panicle was at 100 ppm in golden rod.

Patel (2004) observed highest dry weight of panicle at NAA 125 ppm in golden rod.

2.2.2.8 Number of panicles per plant

Golden rod

Pavagadhi (2001) found that, NAA (125 ppm) increased number of panicles per plant as compared to control in golden rod.

However, Borse (2005) observed that, number of panicles per plant in golden rod was not significantly affected by any treatment of NAA at varied levels i.e. 50, 100 and 150 ppm.

Chrysanthemum

Dutta et al., (1993) noticed that, NAA at all concentrations (50, 75 and 100 ppm) increased number of flowers in cv. 'Co-1'.

Poshiya et al., (1995a) reported that, 30 ppm NAA produced more number of flowers per plant in cv. 'Mayur'.

Sharma et al., (1995) observed that, NAA applied at different concentrations from 25-100 ppm did not effect the number of flowers per plant in cv. 'Move-in-Carvin'.

Marigold

Singh and Rathore (1992) observed that, there was no significant increase in the number of flowers per plant when plants were sprayed with NAA 25, 50 and 100 ppm.
Pandya (2000) observed that, all the concentrations of NAA (100, 200 and 300 ppm) significantly increased the number of flowers per plant as compared to control in cv. 'Lemon Yellow'.

**Gaillardia**

Poshiya *et al.*, (1995a) observed that, among different levels of NAA (15, 30, 45 and 60 ppm), 30 ppm produced highest number of flowers per plant in cv. 'Yellow Giant'.

**Gladiolus**

Maurya and Nagda (2002) reported that, 50 and 100 ppm concentrations of NAA significantly increased number of spike per plant over control in cv. 'Friendship'.

2.2.2.9 **Yield of panicles per plot per ha.**

**Golden rod**

Pavagadhi (2001) reported that, significantly higher yield was recorded at NAA 125 ppm over control in golden rod.

Borse (2005) reported that, significantly higher yield was recorded at NAA 150 ppm over control in golden rod.

**Chrysanthemum**

Dutta *et al.*, (1993) observed that, flower yield increase with NAA 75 ppm in both the seasons in cv.'Co-1'.

Dutta *et al.*, (1995) reported that, significantly higher flower yield per plant was obtained with all levels of NAA (50, 75 and 100 ppm) as compared to control. Same scientists in (1998) observed that, the cut flower yield was highest with 75 ppm NAA treatment.

Poshiya *et al.*, (1995b) also reported higher flower yield in cv. 'Mayur' by application of NAA 30 ppm.

Sharma *et al.*, (1995) observed that, NAA 25-100 ppm resulted in higher flower yield of cv. 'Move-in-Carvin'.

31
Kumar and Ugherja (1998) observed that, all the levels of NAA (25, 75 and 125 ppm) gives significantly higher flower yield as compared to control in cv. 'IIHR-6'.

Marigold
Singh and Rathore (1992) observed no significant effect on flower yield in African marigold by the application of NAA 25, 50 and 100 ppm.

Pandya (2000) recorded significantly higher flower yield with all treatments of NAA (100, 200 and 300 ppm) in cv. 'Lemon Yellow'.

Gaillardia
Poshiya et al., (1995b) recommended 15 ppm NAA for higher flower yield in cv. 'Yellow Giant'.

2.2.2.10 Vase life of panicle (days)

Golden rod
Pavagadhi (2001) reported that, maximum keeping quality (vase life) was obtained at NAA 125 ppm increased number of suckers per plant as compared to control in golden rod.

Borse (2005) reported that, all the treatments of NAA (100 and 150 ppm) takes significantly more days of keeping quality of panicles as compared to control.

Chrysanthemum
Dutta et al., (1993) observed that, 50, 75 and 100 ppm levels of NAA significantly increased the shelf life of flowers over control in cv. 'Co-1'.

Marigold
Pandya (2000) reported that, NAA at 100, 200 and 300 ppm significantly increased the vase life of flowers over control in cv. 'Lemon Yellow'.

32
China aster

Reddy and Sulladmath (1983) reported that, NAA at 30, 45 and 60 ppm did not give significant increase in the vase life of cv. 'Vick's Branching Purple'.

2.3 **EFFECT OF CYCOCEL (CCC)**

Retardation of growth by chemical means has been made possible for many years. Cycocel is known to retard the vegetative growth and so it is known as growth retardant. Weaver (1972) reported that, CCC retarded cell elongation by preventing cell division in sub-apical meristematic region.

2.3.1 **Vegetative Growth Attributes**

2.3.1.1 **Plant height at full bloom stage (cm)**

**Golden rod**

Patil (1996) reported plant, height increased with CCC 500 ppm (50.30 cm) but decreased with 1000 and 2000 ppm as compared to control (46.75 cm) in golden rod.

Wakchaure (2002) recorded that, CCC 1500 ppm increase final plant height with application of low concentration to higher concentration of CCC (1500, 2000 and 2500 ppm) as compared to control in golden rod.

**Chrysanthemum**

Talukdar and Paswan (1994) reported that, CCC at 5000 ppm resulted in the shortest plant of chrysanthemum cv. 'Tumruli', when plants were sprayed with CCC at 5000, 10,000 and 15,000 ppm concentrations. Same scientists also reported in (1997) that, all the levels of CCC treatments (3000, 10,000 and 15,000 ppm) significantly reduced the height of plant as compared to control.

Masu (2004) reported that, foliar spray of CCC at both the levels (500 and 1000 ppm) reduced plant height significantly in cv. 'Local White'.

33
Marigold

Gowda and Jayanthi (1991) reported that, cycocel at 2000 ppm significantly reduced the plant height as compared to control in both seasons (June-July and August-September).

Singh and Rathore (1992) found that, plant height was decreased at all the levels of CCC (2000, 4000 and 8000 ppm) but, significant reductions were found with CCC at 8000 ppm over control.

Yadav (1997) reported that, plant height was significantly reduced when plant sprayed with 1000 ppm CCC in cv. 'Fantastic'.

Pandya (2000) noticed significant reduction in plant height at CCC 750 ppm as compared to control in cv. 'Lemon Yellow'.


Gaillardia

Makwana (1999) found that, plant height was decrease at 2000 and 3000 ppm CCC as compared to control in cv. 'Lorenziana'.

Gladiolus

Ravidas et al., (1992) reported that, CCC 250 ppm significantly reduced plant height in cv. 'Friendship'.

Maurya and Nagda (2002) found that, CCC at both the levels (500 and 1000 ppm) reduced plant height over control in cv. 'Friendship'.

2.3.1.2 Number of suckers per plant at harvesting

Golden rod

Patil (1996) reported increase in number of suckers per plant with low to high concentration of cycocel (500, 1000 and 1500 ppm) in golden rod.

Wakchaure (2002) recorded that, CCC 1500 ppm increased number of suckers per plant with application of low concentration to higher
concentration of CCC (1500, 2000 and 2500 ppm) as compared to control in golden rod.

**Gerbera**

Nair *et al.*, (2002) recorded the minimum number of suckers per plant with CCC 600 and 800 ppm levels.

**Gladiolus**

Ravidas *et al.*, (1992) noticed maximum number of cormels per plant with CCC 500 ppm in cv. 'Friendship'.

2.3.1.3 **Fresh and dry weight of plant (g)**

**Golden rod**

Patil (1996) reported increase in fresh and dry weight of plant with low to high concentration of cycocel (500, 1000 and 1500 ppm) in golden rod.

Wakchaure (2002) recorded that, CCC 1500 ppm increase fresh and dry weight of plant with application of low concentration to higher concentration of CCC (1500, 2000 and 2500 ppm) as compared to control in golden rod.

**Marigold**

Girwani *et al.*, (1990) recorded minimum dry weight of plant with cycocel (500 and 1000 ppm).

Gowda and Jayanthi (1991) recorded the maximum dry weight of plant with cycocel 2000 ppm in both seasons (June-July and August-September) in cv. 'Bangalore Local'.

2.3.2 **Flowering Attributes**

In most of the cases, CCC delay flowering because it restricts the biosynthetic pathway of gibberellin and therefore, it work as antigibberellin (Shrivastava, 1994).
The effect of CCC on flowering parameters in golden rod and different flowering plants have been reported by several workers are being reviewed as below.

### 2.3.2.1 Number of days taken for flower initiation

#### Golden rod

Patil et al., (1996) revealed that, all the concentrations of CCC (500, 1000 and 2000 ppm) required less number of days for first flowering as compared to control.

Patel (2004) reported that, the number of days taken for opening of first flower in plants treated with CCC did not differ much but delayed it with increasing concentration.

#### Chrysanthemum

Dutta et al., (1993) noticed that, CCC 4000 ppm significantly delayed in emergence of first flower over control in cv. 'Co-1'.

Talukdar and Paswan (1997) reported that, CCC 15,000 ppm delayed flower opening when plant sprayed at 30 days after planting in standard type chrysanthemum.

#### Marigold

Khandelwal et al., (2003) observed that, all the treatments of CCC (1000, 2000 and 3000 ppm) required more number of days to first flowering.

#### Gerbera

Nair et al., (2002) reported that, CCC at 400 ppm takes less time for first flowering as compared to control.

#### Gladiolus

Maurya and Nagda (2002) reported that, CCC at 500 and 1000 ppm takes less number of days for first flowering as compared to control in cv. 'Friendship'.
2.3.2.2 Effect on length of panicle (cm)

Golden rod

Patil et al., (1996) reported that, CCC at all concentrations (500, 1000 and 2000 ppm) produced long flower stalk as compared to control.

Patel (2004) reported that, length of panicle (cm) in plants treated with CCC did not differ as compared to control.

Chrysanthemum

Dutta et al., (1993) found that, an application of CCC at all concentrations (2000, 3000 and 4000 ppm) reduced stalk length in cv. 'Co-2'.

Dutta et al., (1995) reported that, CCC at 3000 ppm reduced length of the stalk in chrysanthemum.

Gerbera

Nair et al., (2002) observed that, all the concentrations of CCC (400, 600 and 800 ppm) produced shortest length of flower stalk.

Gladiolus

Ravidas et al., (1992) observed the shortest spike length with all the treatments of CCC (250 and 500 ppm) as compared to control in cv. 'Friendship'.

Mayurya and Nagda (2002) noticed shortest spike length with CCC at 500 and 1000 ppm in cv. 'Friendship'.

2.3.2.3 Number of inflorescence branches per panicle

Golden rod

Patil et al., (1996) reported that, more number of spikelets per flower stalk are produced with all levels of CCC (500, 1000 and 2000 ppm) over control.
Borse (2005) reported minimum number of inflorescence branches per panicle was recorded at CCC 750 ppm (45.06) as compared to control (48.18).

**Gladiolus**

Ravidas *et al.*, (1992) observed that, CCC at 250 and 500 ppm produced less number of florets per spike as compared to control in cv. 'Friendship'. Likewise, Maurya and Nagda (2002) reported that, CCC at 500 and 1000 ppm produced less number of florets per spike as compared to control in cv. 'Friendship'.

### 2.3.2.4 Diameter of cut flower stalk (mm)

Patil (1996) reported that, diameter of panicle increase with the treatment CCC 500 ppm as compared to control in golden rod.

Wakchaure (2002) reported that diameter of main stalk of panicle increase with the treatment CCC 500 ppm as compared to control in golden rod.

Patel (2004) studied diameter of main stalk of panicle increase with the treatment CCC 500 ppm as compared to control in golden rod.

### 2.3.2.5 Longevity of inflorescence *in situ* (days)

**Golden rod**

Patil *et al.*, (1996) reported that, CCC at 500 and 1000 ppm extended longevity of inflorescence over control in golden rod.

Borse (2005) observed that, vase life increased with increase in concentrations of CCC (750 ppm) in golden rod.
2.3.2.6 Fresh weight of panicle

Chrysanthemum

Mohandas (1986) observed higher fresh weight of flowers at 250 ppm CCC, as compared to control. However, it decreased with increase in concentration of CCC (500 and 1000 ppm).

Nagarjuna et al., (1988) reported that foliar spray of CCC 5000 ppm effectively increased fresh weight of flower over control.

Talukdar and Paswan (1996) observed significantly increased the fresh weight of flower, with CCC 10,000 ppm, over control in cv. 'Prof. Harris'.

2.3.2.7 Dry weight of panicle

Chrysanthemum

Mohandas (1986) reported that, an application of CCC 250 ppm significantly increased dry weight of flower as compared to control. However, it decreased with increased concentration of CCC (500 and 1000 ppm).

Marigold

Gowda and Jayanthi (1991) recorded maximum dry weight of flower at 2000 ppm CCC.

2.3.2.8 Number of panicle per plant

Golden rod

Wakchaure (2002) recorded that, CCC 1500 ppm increase number of panicles per plant with application of low concentration to higher concentration of CCC (1500, 2000 and 2500 ppm) as compared to control in golden rod.

Borse (2005) reported lowest number of panicles per plant at all the concentration of CCC (250, 500 and 750 ppm) as compared to control.
Chrysanthemum

According to Dutta et al., (1993) all the treatments of CCC (2000, 3000 and 4000 ppm) gave more number of flowers per plant as compared to control in cv. 'Co-1'.

Talukdar and Paswan (1997) reported that, CCC 5000 ppm produced higher number of flowers per plant over control in cv. 'Maharaja'.

Masu (2004) observed maximum number of flowers per plant with CCC both at 500 and 1000 ppm in cv. 'Local White'.

Marigold

Gowda and Jayanthi (1991) observed that, number of flowers per plant was increased with an increase concentration of CCC (1000, 1500 and 2000 ppm) in African marigold.

Singh and Rathore (1992) found that, CCC 8000 ppm significantly produced more number of flowers per plant over control.

Yadav (1997) obtained significantly higher number of flowers per plant when the plants were treated with CCC 750 ppm as compared to control in cv. 'Fantastic'.

Pandya (2000) reported that, significantly higher number of flowers per plant with cycocel 250 ppm over control in cv. 'Lemon Yellow'. However, number of flowers per plant decreased with higher concentration of CCC (500 and 750 ppm).

Khandelwal et al., (2003) observed that, all the treatments of CCC (1000, 2000, 3000 ppm) produced more number of flowers as compared to control.

Gaillardia

Makwana (1999) observed significantly higher number of flowers per plant with CCC 3000 ppm in cv. 'Lorenziana'.

40
**Gladiolus**

Maurya and Nagda (2002) reported that, CCC at 500 ppm produced significantly higher number of spikes per plant over control in cv. 'Friendship'.

2.3.2.9 Yield of panicle per plot, per ha.

**Golden rod**

Patel (2004) observed significantly decreased yield as compared to control with all concentrations of CCC (500, 1000 and 1500 ppm).

Borse (2005) reported that, foliar spraying of CCC (250, 500 and 750 ppm) decrease the yield of golden rod.

**Chrysanthemum**

Dutta *et al.*, (1993) and (1995) recorded significantly higher flower yield over control, when plant sprayed with CCC 4000 ppm over control, in both the seasons in cv. 'Co-1'.

Masu (2004) reported that, CCC at 500 and 1000 ppm gave maximum yield in cv. 'Local White'.

**Marigold**

Gowda and Jayanthi (1991) reported that, flower yield per plant was increased with CCC 2000 ppm over control, in both seasons (June-July and August-September) in cv. 'Bangalore Local'.

Pandya (2000) reported that, CCC at 250 ppm gave higher yield as compared to control in cv. 'Lemon Yellow'.


**Gaillardia**

Makwana (1999) observed that, all the concentrations of CCC (1000, 2000 and 3000 ppm) gave higher yield over control in cv. 'Lorenziana'.


2.3.2.10 Vase life of panicle (days)

Golden rod

Patil et al., (1996) reported that, CCC at 500 and 1000 ppm extended vase life of flower over control in golden rod.

Borse (2005) observed that, vase life increased with increased concentrations of CCC (750 ppm) in golden rod.

Chrysanthemum

Dutta et al., (1993) observed that, vase life increased with consequent increase in concentrations of CCC (2000, 3000 and 4000 ppm) in cv. 'Co-1'.

Talukdar and Paswan (1997) found that, all the levels of CCC treatment (5000, 10,000 and 15,000 ppm) significantly increased the vase life flowers (in days) as compared to control in cv. 'Maharaja'.

Marigold

Pandya (2000) reported that, maximum vase life of flowers observed with CCC at 500 and 750 ppm in cv. 'Lemon Yellow'.

Gaillardia

Makwana (1999) found that, vase life of flowers increased significantly with linear increase in the concentrations (1000, 2000 and 3000 ppm) of CCC in cv. 'Lorenziana'.

2.4 EFFECT OF PACLOBUTRAZOL (PP333)

Paclobutrazol, a growth retardant, that blocks the conversion of anti-kaurene to kaurinoic acid—a precursor of gibberellin responsible for profuse vegetative growth, and thereby suppress vegetative growth, resulting in dwarf plants without providing any artificial support (Dalziel and Lawrence, 1984; Graebe, 1987).

Paclobutrazol is not readily phloem mobile in most plant species and is most effective, when applied directly to stems or absorbed by roots.
(Barett and Bartuska, 1982). Being a xylem mobile substance, moves upwards with the transpiration stream (Lever et al., 1984; Lever, 1986; Graebe, 1987).

The effect of paclobutrazol on flowering plants has been reported by several workers.

2.4.1 Vegetative Growth Attributes
2.4.1.1 Plant height at full bloom stage (cm)

**Chrysanthemum**

Qrunflesh and Al-Wir (1987) reported that, paclobutrazol 1000, 2000 and 4000 ppm caused significant reduction in plant height of five greenhouse cut-flower cultivars of chrysanthemum.

Muhammad et al., (1997) reported that, among the five levels of paclobutrazol at 500 ppm caused greatest reduction in plant height in *C. morifolium* cv. “Large Flowered Incurve.”

**Rose**

Singh (2002) stated that, the application of 30 mg l⁻¹ paclobutrazol as soil drench, applied at 25 days after pruning, reduced maximum plant height in rose.

2.4.1.2 Fresh and dry weight of plant

**Marigold**

Lee and Lee (1990) reported that, in an experiment with cv. Parade, paclobutrazol was applied at rate of 0.25, 0.5 or 1.0 mg/pot as a soil drench, which significantly reduced dry weights.

Pill and Gunter (2001) revealed that, treating seeds of 'Sensation Mixed' cosmos (*Cosmos bipinnatus*) and 'Bonanza Gold' marigold (*Tagetes patula*) with paclobutrazol (PB) 1000 ppm, during priming of marigold seeds, resulted reduction in shoot dry weight (21%).
2.4.2 Flowering Attributes

2.4.2.1 Number of days taken for flower initiation

Chrysanthemum

Yawale et al., (1998 a) reported that, increasing concentrations of paclobutrazol (0-100 ppm) over control, sprayed at one month after planting, delayed emergence of flower in all four varieties (Viz., Raja. Beauty, Miss R. Thompson and Shefali) in chrysanthemum

Muhammad et al., (1997) observed that, paclobutrazol @ 500 ppm gave the greatest reduction in time of flower initiation over control in C. morifolium cv. ‘Large Flowered Incurve.’

Masu (2004) studied the effects of various treatment on emergence of first flower and found that the root dip method of application of paclobutrazol @ 100 ppm (root dip T1) taken significantly maximum number of days for emergence of first flower (56.25 days) as compared to control, which recorded minimum number of days taken for emergence of first flower (39.50 days).

Parmar (2004) reported that, the minimum days for first bud initiation (27.9) in chrysanthemum was observed in 40 mg l⁻¹ soil drenching with paclobutrazol.

2.4.2.2 Effect on length of panicle (cm)

Elrahem et al., (1993) observed that, paclobutrazol by dipping the tubers before planting of drenching, the growth medium two weeks after planting in the range of 12.5-25.0 ppm (dip) and 2.5-2 mg per pot (drench) reduced the inflorescence length of Aconitum napellus.

While working with Chrysanthemum morifolium cv. ‘Large Flowered Incure’, Muhammad et al., (1997) found significant reduction in Peduncle length with 500 ppm paclobutrazol applied as foliar spary.
Sreekala et al., (2000) noted reduction in spike length of crossandra with 500 ppm paclobutrazol, applied as foliar spray at 30 days after planting.

Mann (2003) found that stalk length in African marigold minimized when treated with paclobutrazol 40 mg/l as soil drench in chrysanthemum.

**Chrysanthemum**

While working with *Chrysanthemum morifolium* cv. ‘Large Flowered Incure’, Muhammad et al., (1997) found significant reduction in Peduncle length with 500 ppm paclobutrazol applied as foliar spary.

Singh (2001) observed that, paclobutrazol applied as foliar spray significantly reduced the stalk length in chrysanthemum as compared to control.

2.4.2.3 **Fresh and dry weight of panicles (g)**

**Chrysanthemum**

Yawale et al., (1998a) concluded in an experiment “to study the effect of the growth-retardant paclobutrazol on fresh weight of flowers”. The results revealed that, the increasing does of paclobutrazol (viz., 0, 25, 50, 75 and 100 ppm) significantly reduced fresh weight of flowers.

Parmar (2004) reported that, the maximum weight of single flower of chrysanthemum was recorded with an application of paclobutrazol 40 mg l⁻¹ as soil drenching.

**Rose**

Singh (2002) found that, higher flower weight was observed when plant treated with foliar spraying of paclobutrazol (50-150 ppm), as
compared to soil drench application of paclobutrazol (10-30 mg/plant) and control in rose cv. 'Black Nigret'.

Singh and Bist (2003) reported that, maximum weight of flower per plant was recorded, when plant treated with soil drench application of paclobutrazol @ 40 mg/plant as compared to control in rose cv. ‘Gruss-an-Teplitz’.

2.4.2.4 Number of panicles per plant

Pinto et al., (2005) reported that, when paclobutrazol (0.5, 0.75 and 1.0 mg a.i. per pot) was applied as a single drench, 40 ml per pot, paclobutrazol (0.5, 0.75 and 1.0 mg a.i. per pot) significantly reduced side branches length.

2.4.2.5 Yield of panicle per plot per ha.

African marigold

Singh (2004) in a study which, African marigold (Tagetes erecta L.) cv. Giant Double African Orange. Applied paclobutrazol (PP333) at 10 and 20 mg/plant as drench, at 30 days after transplanting. PP333 at 20 mg/plant was not found beneficial to improve flower production.

Chrysanthemum

Mann (2004) reported that, the maximum flower yield per plant (571.01g) was recorded in the soil drench method of application of paclobutrazol @ 100 ppm over control.

Parmar (2004) noticed that, maximum flower yield (385.00 g/plant), was obtained in 40 mg-l soil drench with paclobutrazol in chrysanthemum.
2.4.2.6 Vase life of panicle (days)

Gladiolus

Hwang et al., (1986) found that, application of paclobutrazol in cv. Hunting Song, reduced flower life.

Sreekala et al., (2000) noted reduction in spike length of crossandra, with 500 ppm paclobutrazol, applied as foliar spray at 30 days after planting.

Chrysanthemum

Singh (2001) observed that, paclobutrazol applied as foliar spray significantly reduced the stalk length in chrysanthemum as compared to control.

Mann (2003) found that, stalk length in African marigold minimized when treated with 40 mg\textsuperscript{-1} paclobutrazol as soil drench in chrysanthemum.

Parmar (2004) reported that, minimum vase life of chrysanthemum flower was obtained with paclobutrazol 40 mg\textsuperscript{-1} soil drench being 7.0 days.
The details about materials used and techniques adopted during the course of investigation on "Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)" are described in this chapter.

3.1 EXPERIMENTAL SITE

An experiment was conducted at Horticultural Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agriculture University, Junagadh during July 2005 to November 2005 (first flush) and patron crop (second flush) was taken from November 2005 to March, 2006 and the data for all the characters were collected and analysed.

3.1.1 Geographical location of the experimental site

Junagadh is situated at 21.5° N latitude and 70.5° E longitudes with an altitude of 60 meters above the mean sea level, on the western side at the foot hill of mountain Girnar range.

3.2 CLIMATE AND WEATHER CONDITION

Climate is typically subtropical, characterized by fairly cool and dry winter, hot and dry summer and warm and moderately humid monsoon. The rainy season commences by third week of June and end in September. July and August are the months of heavy precipitation. Winter sets in the month of November and continues till the months of February. January is the coldest month of winter. Summer commences in the second fortnight of February and sets in the middle of June. April and May are the hottest months of summer. The data of climatic condition are taken and reported at the Agro-Meteorological Station, Junagadh in India.

It may be seen from the meteorological data that the weather parameters like temperature, relative humidity and sunshine hours were more or less congenial for the growth of golden rod during the year 2005 and 2006.
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It may be seen from the meteorological data that, the weather parameters like temperature, relative humidity and sunshine hours were more or less congenial for the growth of golden rod during the year 2005 and 2006.
Table 1: Meteorological data recorded during the crop season of 2005-06

<table>
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<th>Week No.</th>
<th>Temp. (°C)</th>
<th>Humidity (%)</th>
<th>Rainfall (mm)</th>
<th>Rainy Days</th>
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<td>Min.</td>
<td>Max.</td>
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<td>20.5</td>
<td>46.4</td>
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</table>
3.3 PHYSICO-CHEMICAL PROPERTIES OF THE EXPERIMENT FIELD

The experimental field had an even topography with a gentle slope. The soil samples were drawn randomly before commencement of the experiment from different spots in the field, at the depth of 0-15 and 15-30 cm, and a composite sample was prepared and analyzed for physical and chemical properties of the soil. The detail of analysis along with the methods is presented in Table 2.

The data presented in Table 2 indicated that, the soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH of 7.68. The soil had medium status of organic carbon, available nitrogen, phosphorus and high status of available potash.

3.4 PLANTING MATERIAL

The actively growing herbaceous suckers were selected as a plant material. The suckers were taken from the healthy and diseases free mother plants.

3.5 CULTIVATION DETAILS

The details of cultural operations carried out during the course of investigation are as under:

3.5.1 Preparatory cultivation

The land was thoroughly prepared by ploughing twice with a tractor drawn cultivator followed by planking. Well rotten farm yard manure @ 20 tonnes per hectare was incorporated in the soil before the last ploughing. Then marking was done as per layout (Fig. 1).

3.5.2 Application of fertilizers

Chemical fertilizers were applied @ 100 kg of nitrogen, 100 kg of phosphorus and 100 kg of potash per hectare.

Full dose of phosphorus, potash and half dose of nitrogen was applied as a basal dose, uniformly to all the plots, and the remaining half dose...
Table 2: Mechanical and chemical analysis of experimental soil

<table>
<thead>
<tr>
<th>Particular</th>
<th>Value of different soil depth (cm)</th>
<th>Method employed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
<td>15-30</td>
</tr>
<tr>
<td><strong>Mechanical determination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (%)</td>
<td>26.65</td>
<td>26.12</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>21.33</td>
<td>26.15</td>
</tr>
<tr>
<td>Clay (%)</td>
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<td>49.55</td>
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<tr>
<td><strong>Chemical determination</strong></td>
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<td></td>
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<tr>
<td>Available N (kg/ha)</td>
<td>250.32</td>
<td>234.31</td>
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<tr>
<td>Available P₂O₅ (kg/ha)</td>
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<td>28.48</td>
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<tr>
<td>Available K₂O (kg/ha)</td>
<td>242.23</td>
<td>225.11</td>
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<tr>
<td>Organic carbon (%)</td>
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<tr>
<td>Soil pH (1:2.5, Soil water ratio)</td>
<td>7.44</td>
<td>7.68</td>
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<tr>
<td>Electrical conductivity (dam)</td>
<td>0.23</td>
<td>0.25</td>
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<tr>
<td>(1:2.5, Soil water ratio)</td>
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</table>
Fig. 1: Layout of experimental plot. *T1 and *T14 water spray (control)
of nitrogen was applied one month after the transplanting. Irrigation was given before fertilization to the crop for maintaining soil moisture.

Nitrogen, phosphorus and potash were applied in the form of Urea, Single super phosphate and Murate of potash, respectively.

3.5.3 Transplanting of golden rod suckers

Transplanting of golden rod suckers was done on 18th July, 2005. Size were prepared at 30 x 30 cm distance in the plots and suckers were planted.

3.5.4 Irrigation

A light irrigation was given immediately after planting of suckers in the field for proper establishment of suckers. The plots were given uniform irrigation thereafter at the intervals of 7 to 8 days, depending on the moisture condition of the experimental plot.

3.5.5 Plant protection

Hand weeding was carried out as and when required. However, no any serious incidence of insect pest and disease infestation was observed during the period of experiment.

3.5.6 Harvesting

The panicles were harvested at 25 per cent flower opening stage at early in the morning with the help of secature. Immediately after harvesting, the bottom end of panicles was put in water.

3.6 TREATMENT MATERIALS

Plant growth regulators i.e. GA₃, NAA, CCC and Paclobutrazol, were obtained from Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh.
3.7 EXPERIMENTAL DETAILS

3.7.1 Location : Horticultural Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University Junagadh.

3.7.2 Year of Experiment : 2005-2006

3.7.3 Experimental Design : Randomized Block Design

3.7.4 No. of Replications : 3 (Three)

3.7.5 No. of Plots : 39

3.7.6 Spacing : 30 x 30 cm

3.7.7 Plot size : Gross plot : 1.8 x 3.0 m
               Net plot : 1.5 x 2.5 m

3.7.8 Total Experimental Area : 308.70 Sq. m.

3.7.9 i) No. of plants per gross plot : 50
ii) No. of plants per net plot : 24
3.7.10 **TREATMENTS**

In this investigation, 13 treatments of gibberellic acid (GA₃), naphthalene acetic acid (NAA), cycocel (CCC) and Paclobutrazol (PP333), each consisting of three levels along with control (Distilled water spray) were tried. The details of treatments are presented in Table 3.3

**Table 3. Treatment details**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatment No.</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₁</td>
<td>Control (Distilled water spray)</td>
</tr>
<tr>
<td>2.</td>
<td>T₂</td>
<td>GA₃ 25 ppm</td>
</tr>
<tr>
<td>3.</td>
<td>T₃</td>
<td>GA₃ 50 ppm</td>
</tr>
<tr>
<td>4.</td>
<td>T₄</td>
<td>GA₃ 100 ppm</td>
</tr>
<tr>
<td>5.</td>
<td>T₅</td>
<td>NAA 25 ppm</td>
</tr>
<tr>
<td>6.</td>
<td>T₆</td>
<td>NAA 50 ppm</td>
</tr>
<tr>
<td>7.</td>
<td>T₇</td>
<td>NAA 100 ppm</td>
</tr>
<tr>
<td>8.</td>
<td>T₈</td>
<td>CCC 500 ppm</td>
</tr>
<tr>
<td>9.</td>
<td>T₉</td>
<td>CCC 1000 ppm</td>
</tr>
<tr>
<td>10.</td>
<td>T₁₀</td>
<td>CCC 2000 ppm</td>
</tr>
<tr>
<td>11.</td>
<td>T₁₁</td>
<td>Paclobutrazol 250 ppm</td>
</tr>
<tr>
<td>12.</td>
<td>T₁₂</td>
<td>Paclobutrazol 500 ppm</td>
</tr>
<tr>
<td>13.</td>
<td>T₁₃</td>
<td>Paclobutrazol 1000 ppm</td>
</tr>
</tbody>
</table>

3.7.11 **Number of sprays** : 2 (30 and 45 days after transplanting)
3.8 APPLICATION OF GROWTH REGULATORS

In the experiment, three levels each of Gibberelllic acid (25, 50 and 100 ppm), Cycocel (500, 1000 and 2000 ppm), Naphthalene acetic acid (25, 50 and 100 ppm) and Paclobutrazol (250, 500 and 1000) were tried.

3.8.1 Preparation of solutions

(A) Gibberelllic acid (GA₃)

Stock solution of 100 ppm GA₃ (2000 ml) was prepared by dissolving 0.2 g of GA₃ in small quantity of 60 per cent alcohol (just sufficient to dissolve the powder of GA₃) and diluted in distilled water to make final volume 2000 ml. Out of this stock solution, 1000 ml solution was used as working solution of 100 ppm. Then to prepare the working solution of 25 and 50 ppm GA₃, 250 and 500 ml of stock solution was taken and diluted in 750 and 500 ml distilled water, respectively. For second spraying, same procedure for preparation of solution was followed.

(B) Cycocel (CCC)

Stock solution of 2000 ppm CCC (2000 ml) was prepared by dissolving 8.0 ml of CCC in 2000 ml distilled water. Out of this stock solution, 1000 ml of solution was used as working solution of 2000 ppm. Then to prepare the working solution of 1000 and 500 ppm CCC, 500 and 250 ml of stock solution was taken and diluted in 500 and 750 ml of distilled water, respectively. For second spraying, same procedure for preparation of solution was followed.

(C) Naphthalene acetic acid (NAA)

Stock solution of 100 ppm NAA (2000 ml) was prepared by dissolving 0.2 g of NAA in 1.0 per cent Sodium hydroxide (just sufficient to dissolve the powder of NAA) and diluted in distilled water to make final volume of 1000 ml. Out of this 1000 ml of solution, was used as working solution of 100 ppm. Then to prepare the working solution of 25 and 50 ppm NAA, 250 and 500 ml of stock solution was taken and diluted in 750 and 500
ml distilled water, respectively. For second spraying same procedure for preparation of solution was followed.

(D) **Paclobutrazol (PP333)**

Stock solution of 1000 ppm Paclobutrazol (2000 ml) was prepared by dissolving 8.0 ml of Paclobutrazol in 2000 ml distilled water. Out of this solution 1000 ml of solution was used as working solution of 1000 ppm. Then to prepare the working solution of 500 and 250 ppm Paclobutrazol, 500 and 250 ml of stock solution was taken and diluted in 500 and 750 ml distilled water, respectively. For second spraying same procedure for preparation of solution was followed.

3.8.2 **Spraying technique for growth substances**

Spraying of solution of growth substances was done uniformly with the help of garden baby sprayer. All the leaves were thoroughly sprayed from all the sides.

3.8.3 **Time of application**

Foliar sprays were given at 30 and 45 days after transplanting, during morning hours.

3.9 **OBSERVATIONS RECORDED**

The observations recorded and their methodology adopted during the course of investigation is discussed here as under:

Five plants were selected at random from each net plot and tagged to record the observations.

3.9.1 **Vegetative growth attributes**

3.9.1.1 **Plant height at full bloom stage (cm)**

Golden rod is a rosette type of plant with a spreading habit. So, height of golden rod plant remains dwarf to medium. The observation of plant height was recorded after harvesting panicle from each five-tagged plant.
3.9.1.2 Number of suckers per plant at harvesting
The number of suckers arising from plant was counted from five tagged plants in each net plot, at the end of an experiment.

3.9.1.3 Fresh weight of plants (g)
After harvesting of panicles, five tagged plants from each net plot were uprooted and immediately weighted and data were recorded.

3.9.1.4 Dry weight of plants (g)
After recording fresh weight, five tagged plants from each net plots were air dried under shade in the laboratory and later on they were oven dried at 65°C till constant weight. Dry weight of each plant was then recorded.

3.9.2 Flowering attributes

3.9.2.1 Number of days taken for flower initiation
The number of days taken from transplanting to opening of panicles was recorded.

3.9.2.2 Length of panicle (cm)
Length of an individual panicle from five tagged plants of each net plot was recorded after harvesting.

3.9.2.3 Number of inflorescence branches per panicle
Number of inflorescence branches of an individual panicle of five tagged plants from each net plot was recorded after harvesting.

3.9.2.4 Diameter of cut flower stalk (cm)
Diameter of cut flower stalk was recorded immediately after harvesting by using Vernier calipers.

3.9.2.5 Longevity of panicle in situ (days)
Longevity of an individual panicle in situ was recorded in number of days.

3.9.2.6 Fresh weight of panicle (g)
Fresh weight of panicle of each tagged plants was recorded immediately after harvest.
3.9.2.7 Dry weight of panicle (g)
After recording fresh weight, the panicles were air dried under shade in the laboratory and later on they were oven dried, at 65°C, till constant weight, and their dry weight was recorded.

3.9.2.8 Number of panicles per plant
The number of panicles harvested per tagged plant from each net plot was recorded.

3.10 YIELD

Yield of panicles per plot, per hectare
Yield of panicles per plot was recorded and computed to hectare basis to reflect yield per hectare.

3.11 Vase life of panicle (days)
Immediately after harvesting the base portion of five panicles of uniform size from each experimental plot, were kept in flask containing tap water. The water level in each flask was maintained at the initial level throughout the experiment. The keeping quality of an individual panicle was expressed as the number of days from harvest, until panicle was no longer fit to be retained as cut flower.

3.12 ECONOMICS

In order to evaluate the effectiveness of different treatments and to ascertain the most remunerative treatment, the expenses incurred in all cultural operations from preparation of land to harvest of the crop includes as cost of inputs viz., growth regulators, seedlings, fertilizers, irrigation etc. applied to each treatment were computed.

The gross realization was worked out on the basis of mean flower yield per hectare of each treatment, and the prevailing market price of flower. The net realization per hectare was calculated by deducting the cost of cultivation from the gross realization for each treatment and recorded
accordingly. The Cost Benefit Ratio (CBR) was calculated on the basis of the formula given below:

\[
C.B.R. = \frac{\text{Gross realization (Rs./ha)}}{\text{Total cost of cultivation (Rs./ha)}}
\]

3.13 STATISTICAL ANALYSIS

The data collected for all the characters studied, were subjected to statistical analysis by adopting 'Analysis of variance' technique as described by Panse and Sukhatme (1985). The treatment difference was tested by 'F' test of significance on the basis of null hypothesis. The standard error (S.Em.±) was calculated in each case. The critical difference (C.D.) at 5% level of probability was worked out to compare the treatment means. The value of coefficient of variation (C.V. %) was also calculated.
Experimental Results

The field experiment entitled “Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)”, first flush was carried out during July 2005 to November 2005 and second flush (retson crop) was carried out during November 2005 to March 2006 at the field of Horticulture Instructional Farm, Department of Horticulture, College of Agriculture, J.A.U., Junagadh. The data recorded during the experiments were analyzed statistically, and results of each character are presented in this chapter.

4.1 GROWTH ATTRIBUTES

4.1.1 Plant height at full bloom stage (cm)

The data on plant height as influenced by various plant growth regulators at varied levels was recorded at full-bloom stage are presented in Table 4 and graphically depicted in Fig. 4.1.

The most data revealed that, GA₃ 100 ppm produced significantly highest plant height (125.00 cm), which was at par with the treatment NAA 100 ppm (122.80 cm). The treatment NAA 100 ppm was at par with GA₃ 25 and 50 ppm. Significantly the lowest plant height (100.83 cm) was observed in treatment central, which was at par with all the levels of pitholemsat (250, 750 and 1000 ppm), and CCC (500, 1000 and 2000 ppm).

4.1.2 Numbers of suckers per plant

Data recorded on the influence of different levels of plant growth regulators with respect to number of suckers per plant found to be significant. This has been shown in Table 5 and depicted in Fig. 4.2.

The treatment NAA 100 ppm also influenced number of suckers per plant, and it was at par with GA₃ 25 and 50 ppm, and CCC 500 ppm.
IV. EXPERIMENTAL RESULTS

The field experiment entitled “Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)”, first flush was carried out during July 2005 to November 2005 and second flush (ratoon crop) was carried out during November 2005 to March 2006 at the field of Horticulture Instructional Farm, Department of Horticulture, College of Agriculture, J.A.U., Junagadh. The data recorded during the experiment, were analyzed statistically, and results of each character are presented in this chapter.

4.1 GROWTH ATTRIBUTES

4.1.1 Plant height at full bloom stage (cm)

The data on plant height as influenced by various plant growth regulators at varied levels was recorded at full bloom stage are presented in Table 4 and graphically depicted in Fig. 4.1.

The mean data revealed that, GA₃ 100 ppm produced significantly highest plant height (125.00 cm), which was at par with the treatment NAA 100 ppm (122.80 cm). The treatment NAA 100 ppm was at par with GA₃ 25 and 50 ppm. Significantly the lowest plant height (100.83 cm) was observed in treatment control, which was at par with all the levels of paclobutrazol (250, 500 and 1000 ppm), and CCC (500, 1000 and 2000 ppm).

4.1.2 Numbers of suckers per plant

Data recorded on the influences of different levels of plant growth regulators with respect to number of suckers per plant found to be significant. That has been shown in Table 5 and depicted in Fig. 4.2.

Average data revealed that, GA₃ 100 ppm produced significantly higher number of suckers (7.86) per plant and it was at par with NAA 100 ppm (7.04).

The treatment NAA 100 ppm also influenced number of suckers per plant, and it was at par with GA₃ 25 and 50 ppm, and CCC 500 ppm.
Table 4: Effect of growth regulators on plant height at full bloom stage

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Plant height at full bloom stage (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Control</td>
<td>100.83</td>
</tr>
<tr>
<td>T2</td>
<td>GA₃ 25</td>
<td>111.98</td>
</tr>
<tr>
<td>T3</td>
<td>GA₃ 50</td>
<td>116.10</td>
</tr>
<tr>
<td>T4</td>
<td>GA₃ 100</td>
<td>125.00</td>
</tr>
<tr>
<td>T5</td>
<td>NAA 25</td>
<td>112.80</td>
</tr>
<tr>
<td>T6</td>
<td>NAA 50</td>
<td>113.92</td>
</tr>
<tr>
<td>T7</td>
<td>NAA 100</td>
<td>122.80</td>
</tr>
<tr>
<td>T8</td>
<td>CCC 500</td>
<td>107.68</td>
</tr>
<tr>
<td>T9</td>
<td>CCC 1000</td>
<td>107.92</td>
</tr>
<tr>
<td>T10</td>
<td>CCC 2000</td>
<td>104.77</td>
</tr>
<tr>
<td>T11</td>
<td>Paclobutrazol 250</td>
<td>101.63</td>
</tr>
<tr>
<td>T12</td>
<td>Paclobutrazol 500</td>
<td>103.13</td>
</tr>
<tr>
<td>T13</td>
<td>Paclobutrazol 1000</td>
<td>103.53</td>
</tr>
</tbody>
</table>

S.Em. ± 2.86
C.D. at 5% 8.35
C.V. % 4.50
Fig 4.1: Effect of growth regulators on plant height at full bloom stage
Table 5: Effect of growth regulators on number of suckers per plant at harvesting

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Number of suckers per plant at harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>Control</td>
<td>4.80</td>
</tr>
<tr>
<td>T₂</td>
<td>GA₃ 25</td>
<td>6.30</td>
</tr>
<tr>
<td>T₃</td>
<td>GA₃ 50</td>
<td>6.60</td>
</tr>
<tr>
<td>T₄</td>
<td>GA₃ 100</td>
<td>7.86</td>
</tr>
<tr>
<td>T₅</td>
<td>NAA 25</td>
<td>5.56</td>
</tr>
<tr>
<td>T₆</td>
<td>NAA 50</td>
<td>5.73</td>
</tr>
<tr>
<td>T₇</td>
<td>NAA 100</td>
<td>7.04</td>
</tr>
<tr>
<td>T₈</td>
<td>CCC 500</td>
<td>6.28</td>
</tr>
<tr>
<td>T₉</td>
<td>CCC 1000</td>
<td>5.22</td>
</tr>
<tr>
<td>T₁₀</td>
<td>CCC 2000</td>
<td>5.09</td>
</tr>
<tr>
<td>T₁₁</td>
<td>Paclobutrazol 250</td>
<td>4.90</td>
</tr>
<tr>
<td>T₁₂</td>
<td>Paclobutrazol 500</td>
<td>4.66</td>
</tr>
<tr>
<td>T₁₃</td>
<td>Paclobutrazol 1000</td>
<td>4.55</td>
</tr>
<tr>
<td></td>
<td>S.Em. ±</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>C.D. at 5%</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>C.V. %</td>
<td>12.64</td>
</tr>
</tbody>
</table>
Fig 4.2: Effect of growth regulators on number of suckers per plant at harvest
Significantly lowest number of suckers (4.55) was observed under paclobutrazol 1000 ppm. This was at par with the treatment paclobutrazol 500 and 250 ppm, control, CCC 2000 and 1000 ppm, NAA 25 and 50 ppm.

4.1.3 **Effect on fresh weight of plant (g)**

The mean data collected at varied levels of growth regulators on fresh weight of plant are presented in Table 6 and graphically depicted in Fig. 4.3.

Significantly the highest fresh weight of plant was obtained with the treatment GA$_3$ 100 ppm (238.48 g). It was at par with the treatment NAA 100 ppm (249.74 g). Treatment NAA 100 ppm was at par with the treatments GA$_3$ 25 ppm, GA$_3$ 50 ppm and CCC 500 ppm. Significantly the lowest fresh weight was obtained under control (188.59 g), and it was found at par with all the level of Paclobutrazol (250, 500 and 1000 ppm) as well as CCC 1000 and 2000 ppm.

4.1.4 **Effect on dry weight of plant (g)**

Observations pertaining to dry weight of plant as affected by different levels of plant growth regulators found to be significant and presented in Table 6 and depicted in Fig. 4.3.

The mean data revealed that, maximum dry weight of plant (91.45 g) was obtained from GA$_3$ 100 ppm, which was at par with NAA 100 ppm (81.88 g). The treatment NAA 100 ppm was at par with CCC 500 ppm and Paclobutrazol 250 ppm. Significantly the minimum dry weight of plant was recorded in control (50.66 g), and it was at par with the treatments NAA 25 ppm, CCC 1000 ppm, Paclobutrazol 500 and Paclobutrazol 1000 ppm.

4.1.5 **Effect of ratoon crop**

The data on growth attributes were collected and analysed. The results indicated that, there was no any residual influence of growth regulators sprayed in previous flush because, the data were found non significant as compared to water spray (control).
Table 6: Effect of growth regulators on fresh and dry weight of plant

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Fresh weight of plant (g)</th>
<th>Dry weight of plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Control</td>
<td>188.59</td>
<td>50.66</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 25</td>
<td>228.37</td>
<td>71.21</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 50</td>
<td>232.49</td>
<td>76.25</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 100</td>
<td>258.48</td>
<td>91.45</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt;</td>
<td>NAA 25</td>
<td>219.70</td>
<td>61.86</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt;</td>
<td>NAA 50</td>
<td>223.72</td>
<td>66.94</td>
</tr>
<tr>
<td>T&lt;sub&gt;7&lt;/sub&gt;</td>
<td>NAA 100</td>
<td>249.74</td>
<td>81.88</td>
</tr>
<tr>
<td>T&lt;sub&gt;8&lt;/sub&gt;</td>
<td>CCC 500</td>
<td>225.55</td>
<td>67.11</td>
</tr>
<tr>
<td>T&lt;sub&gt;9&lt;/sub&gt;</td>
<td>CCC 1000</td>
<td>199.10</td>
<td>61.42</td>
</tr>
<tr>
<td>T&lt;sub&gt;10&lt;/sub&gt;</td>
<td>CCC 2000</td>
<td>194.69</td>
<td>66.39</td>
</tr>
<tr>
<td>T&lt;sub&gt;11&lt;/sub&gt;</td>
<td>Paclobutrazol 250</td>
<td>193.50</td>
<td>67.64</td>
</tr>
<tr>
<td>T&lt;sub&gt;12&lt;/sub&gt;</td>
<td>Paclobutrazol 500</td>
<td>191.41</td>
<td>65.39</td>
</tr>
<tr>
<td>T&lt;sub&gt;13&lt;/sub&gt;</td>
<td>Paclobutrazol 1000</td>
<td>189.39</td>
<td>63.57</td>
</tr>
</tbody>
</table>

S.Em. ±       | 8.31                 | 5.06                      |

C.D. at 5%    | 24.25                | 14.77                     |

C.V. %        | 6.69                 | 12.78                     |
Fig 4.3: Effect of growth regulators on fresh and dry weight of plant
FLOWERING ATTRIBUTES

The mean data on flowering parameters as influenced by different levels of plant growth regulators were recorded during the experimentation are presented as under.

4.2.1 Effect on number of days taken for first flower initiation

The data on number of days taken for first flower initiation are presented in Table 7 and depicted in Fig. 4.4.

The results revealed that, the treatment GA3 100 ppm significantly took lowest number of days, for first flower initiation (60.04 days), and it was at par with NAA 100 ppm (65.17 days) and CCC 500 ppm (65.24 days). On the other hand, control taken maximum number of days for first flower initiation (81.53 days) and it was at par with the treatment CCC (1000 and 2000 ppm) and NAA (25 and 50 ppm) and all the levels of Paclobutrazol.

4.2.2 Effect on length of panicle (cm)

Observations pertaining to length of panicle as affected by different levels of plant growth regulators, found to be significant, which has been presented in Table 8 and depicted in Fig. 4.5.

Significantly the highest length of panicle (103.03 cm) was resulted from the treatment GA3 100 ppm and it was at par with NAA 100 ppm (101.20 cm) and CCC 500 ppm (100.87 cm). The lowest length of panicle was observed in the control (76.74 cm), which was at par with the treatment of GA3 25 and 50 ppm, NAA 25 and 50 ppm, CCC 1000 and 2000 ppm and all the levels of Paclobutrazol.

4.2.3 Effect on number of inflorescence branches per panicle

Data collected on the effect of various plant growth regulators at varied levels on number of inflorescence branches per panicle have been presented in Table 9 and graphically depicted in Fig. 4.6.

It is clear from the table that, plant growth regulator treatments significantly influenced the number of inflorescence branches per panicle. Among the various treatments significantly the highest number of inflorescence
Table 7: Effect on number of days taken for flower initiation

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Number of days taken for flower initiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Control</td>
<td>81.53</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 25</td>
<td>70.13</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 50</td>
<td>69.19</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>GA&lt;sub&gt;3&lt;/sub&gt; 100</td>
<td>60.04</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt;</td>
<td>NAA 25</td>
<td>70.78</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt;</td>
<td>NAA 50</td>
<td>68.62</td>
</tr>
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<td>T&lt;sub&gt;7&lt;/sub&gt;</td>
<td>NAA 100</td>
<td>65.17</td>
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<td>T&lt;sub&gt;8&lt;/sub&gt;</td>
<td>CCC 500</td>
<td>65.24</td>
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<td>CCC 1000</td>
<td>72.54</td>
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<td>T&lt;sub&gt;10&lt;/sub&gt;</td>
<td>CCC 2000</td>
<td>73.23</td>
</tr>
<tr>
<td>T&lt;sub&gt;11&lt;/sub&gt;</td>
<td>Paclobutrazol 250</td>
<td>77.63</td>
</tr>
<tr>
<td>T&lt;sub&gt;12&lt;/sub&gt;</td>
<td>Paclobutrazol 500</td>
<td>75.55</td>
</tr>
<tr>
<td>T&lt;sub&gt;13&lt;/sub&gt;</td>
<td>Paclobutrazol 1000</td>
<td>74.57</td>
</tr>
<tr>
<td>S.Em. ±</td>
<td></td>
<td>2.79</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td></td>
<td>8.15</td>
</tr>
<tr>
<td>C.V. %</td>
<td></td>
<td>6.80</td>
</tr>
</tbody>
</table>
Fig 4.4 : Effect of growth regulators on number of days taken for flower initiation
Table 8: Effect of growth regulators on length of panicle (cm)

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Length of panicle (cm)</th>
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<tbody>
<tr>
<td>T₁</td>
<td>Control</td>
<td>76.74</td>
</tr>
<tr>
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<td>GA₃ 25</td>
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</tr>
<tr>
<td>T₃</td>
<td>GA₃ 50</td>
<td>86.56</td>
</tr>
<tr>
<td>T₄</td>
<td>GA₃ 100</td>
<td>103.03</td>
</tr>
<tr>
<td>T₅</td>
<td>NAA 25</td>
<td>84.59</td>
</tr>
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<td>NAA 50</td>
<td>86.64</td>
</tr>
<tr>
<td>T₇</td>
<td>NAA 100</td>
<td>101.20</td>
</tr>
<tr>
<td>T₈</td>
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<td>81.63</td>
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<td>Paclobutrazol 1000</td>
<td>81.73</td>
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</table>

S.Em. ±: 3.80
C.D. at 5%: 11.10
C.V. %: 7.63
Fig 4.5: Effect of growth regulators on length of panicle
Table 9: Effect of growth regulators on number of inflorescence branches per panicle

<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Number of inflorescence branches per panicle</th>
</tr>
</thead>
<tbody>
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</tr>
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<td>T₂</td>
<td>GA₃ 25</td>
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<td>GA₃ 100</td>
<td>65.23</td>
</tr>
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<td>T₅</td>
<td>NAA 25</td>
<td>52.37</td>
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<td>NAA 50</td>
<td>52.65</td>
</tr>
<tr>
<td>T₇</td>
<td>NAA 100</td>
<td>64.43</td>
</tr>
<tr>
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<td>CCC 500</td>
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<td>CCC 1000</td>
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<td>52.63</td>
</tr>
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<td>T₁₁</td>
<td>Paclobutrazol 250</td>
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</tr>
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<td>Paclobutrazol 500</td>
<td>46.06</td>
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<tr>
<td>T₁₃</td>
<td>Paclobutrazol 1000</td>
<td>47.37</td>
</tr>
</tbody>
</table>

S.Em. ± 3.35
C.D. at 5% 9.77
C.V. % 11.18
Fig 4.6: Effect of growth regulators on number of inflorescence branches per panicle
branches per panicle was observed at GA₃ 100 ppm (65.23) and it was at par with treatment NAA 100 ppm (64.43). Significantly the lowest number of inflorescence branches per panicle (43.17) was with control. However, all the levels of Paclobutrazol (250, 500 1000 ppm), CCC (500, 1000, and 2000 ppm), GA₃ (25 ppm) and NAA (25 and 50 ppm) were found at par with control.

4.2.4 Diameter of cut flower stalk (mm)

Difference in diameter of cut flower stalk under, different level of plant growth regulators, found to be significant. This has been presented in Table 10 and depicted in Fig. 4.7.

The mean data revealed that, significantly maximum diameter of cut flower stalk (6.42 mm) was recorded in the treatment GA₃ 100 ppm, which was at par with GA₃ 50 ppm (5.13 mm) and NAA 100 ppm (4.63 mm), Significantly minimum diameter of cut flower stalk (2.81 mm) was recorded under control, which was at par with all the levels of CCC (500, 1000 and 2000 ppm) and Paclobutrazol (250, 500 and 1000 ppm).

4.2.5 Effect on Vase life of panicle (days)

Data collected on the effect of various plant growth regulators at varied levels on vase life of panicles have been presented in Table 11 and graphically shown in Fig. 4.8.

It is clear from the table that, all treatments significantly influenced the vase life of panicles. Among the various treatments significantly the maximum days of vase life of panicle was observed at the treatment CCC 500 ppm (7.10 days), which was at par with the treatment GA₃ 100 ppm (6.89 days), NAA 100 ppm (6.76 days) and CCC 1000 ppm (6.54 days). Significantly the minimum days of vase life of panicles was observed with control (3.93 days), which was at par with the treatment NAA 50 ppm (4.05 days) and GA₃ 100 ppm (4.31 days).
<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Diameter of cut flower stalk (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Control</td>
<td>2.81</td>
</tr>
<tr>
<td>T2</td>
<td>GA₃ 25</td>
<td>4.18</td>
</tr>
<tr>
<td>T3</td>
<td>GA₃ 50</td>
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<td>3.88</td>
</tr>
<tr>
<td>T6</td>
<td>NAA 50</td>
<td>3.92</td>
</tr>
<tr>
<td>T7</td>
<td>NAA 100</td>
<td>4.63</td>
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<td>CCC 500</td>
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<td>T12</td>
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</tr>
<tr>
<td>T13</td>
<td>Paclobutrazol 1000</td>
<td>2.87</td>
</tr>
<tr>
<td>S.Em. ±</td>
<td></td>
<td>0.24</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td></td>
<td>0.70</td>
</tr>
<tr>
<td>C.V. %</td>
<td></td>
<td>10.96</td>
</tr>
</tbody>
</table>
Fig 4.7: Effect of growth regulators on diameter of cut flower stalk
4.2.6 Longevity of inflorescence in situ (days)

Observations pertaining to longevity of inflorescence in situ, as affected by different levels of plant growth regulators were found to be significant and presented in Table 11 and depicted graphically in Fig. 4.8.

Significantly the maximum longevity of inflorescence in situ (17.49 days) was recorded in CCC 500 ppm, which was at par with the treatment GA\textsubscript{3} 100 ppm (17.00 days), NAA 100 ppm (16.95 days).

Significantly the minimum longevity of inflorescence in situ (10.77 days) was observed under control, which was at par with the treatments GA\textsubscript{3} 25 ppm, GA\textsubscript{3} 50 ppm, NAA 25 ppm, NAA 50 ppm, CCC 1000 ppm, CCC 2000 ppm, Paclobutrazol 250 ppm, Paclobutrazol 500 ppm and Paclobutrazol 1000 ppm.

4.2.7 Fresh weight of panicle (g)

Data collected on the effect of various plant growth regulators at varied levels on fresh weight of panicle are presented in Table 12 and depicted graphically in Fig. 4.9.

It was observed from the data that significantly maximum fresh weight of panicle was recorded at GA\textsubscript{3} 100 ppm (158.48 g), which was at par with the treatment NAA 100 ppm (149.74 g). Significantly the minimum fresh weight of panicle was observed in control (88.59 g), which was at par with GA\textsubscript{3} 25 ppm (108.37g), NAA 25 ppm (109.70g), CCC 1000 and 2000 ppm and all the levels of Paclobutrazol (250, 500 and 1000 ppm).

4.2.8 Dry weight of panicle (g)

The data pertaining to dry weight of panicle for different levels of plant growth regulators, found to be significant and presented in Table 12 and depicted graphically in Fig. 4.9.

Significantly the maximum dry weight of panicle was recorded by the treatment GA\textsubscript{3} 100 ppm (83.48 g). Treatment NAA 100 ppm (66.41 g) was found significantly superior over control, but it was found at par with GA\textsubscript{3} 25 ppm, GA\textsubscript{3} 50 ppm, T\textsubscript{5} NAA 25 ppm, and T\textsubscript{6} NAA 50 ppm. Significantly the
<table>
<thead>
<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Longevity of panicle in situ (days)</th>
<th>Vase life of panicle (days)</th>
</tr>
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<tr>
<td>T₁</td>
<td>Control</td>
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<td>3.93</td>
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<td>GA₃ 25</td>
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<td>GA₃ 50</td>
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<td>5.10</td>
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<td>GA₃ 100</td>
<td>17.00</td>
<td>6.89</td>
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<td>12.06</td>
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<td>C.V. %</td>
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Fig 4.8: Effect of growth regulators on vase life and longevity of panicle in situ
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<th>Dry weight of panicle (g)</th>
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<td>GA₃ 50</td>
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<td>GA₃ 100</td>
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<td>63.72</td>
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<td>40.41</td>
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<td>8.31</td>
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<tr>
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<td></td>
<td>12.77</td>
<td>19.14</td>
</tr>
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</table>
Fig 4.9: Effect of growth regulators on fresh and dry weight of panicle
minimum dry weight of panicle was found in the treatment paclobutrazol 1000 ppm (39.39g), which was at par with control (40.59g), and all the levels of CCC (500, 1000 and 2000 ppm) and Paclobutrazol (250 500 and 1000 ppm).

4.2.9 Effect of ratoon crop

The data on flowering attributes were collected and analysed. The results indicated that, there was no any residual influence of growth regulators sprayed in previous flush because, the data were found non significant as compared to water spray (control).

4.2.10 Yield of panicle per plant

Data collected on the effect of various plant growth regulators at, varied levels on yield of panicles per plant have been presented in Table 13 and graphically shown in Fig. 4.10.

It is clear from the table that, different treatments significantly influence the yield of panicles per plant. Among the various treatments significantly the highest yield of panicles per plant was observed at the treatment GA₃ 100 ppm (5.23), which was at par with the treatment NAA 100 ppm (4.65). NAA 100 ppm and GA₃ 50 ppm. Significantly lowest yield of panicles per plant was observed with CCC 2000 ppm (1.82), which was at par with the treatment CCC 1000 ppm, CCC 500 ppm, control, Paclobutrazol 1000 ppm, Paclobutrazol 500 ppm, Paclobutrazol 250 ppm and NAA 25 ppm.

4.2.11 Effect on yield of panicles per plot

Data collected on the effect of various plant growth regulators at varied levels on yield of panicles per plot have been presented in Table 13.

It is clear from the table that different treatments significantly influenced the yield of panicles per plot. Among the various treatments significantly the highest yield of panicles per plot was observed at the treatment GA₃ 100 ppm (125.52), which was at par with the treatment NAA 100 ppm (111.60). Significantly the lowest yield of panicles per plant was observed with CCC 2000 ppm (43.68), which was at par with the treatment CCC 1000 ppm
<table>
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<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Yield of panicles</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per plant</td>
<td>Per plot</td>
<td>Per hectare</td>
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</tr>
<tr>
<td>T1</td>
<td>Control</td>
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<td>52.32</td>
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<td>CCC 1000</td>
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<td>17.72</td>
<td>17.72</td>
<td></td>
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</tbody>
</table>
Fig 4.10: Effect of growth regulators on yield of panicles per plant
Experimental Results

(48.72), CCC 500 ppm (57.36), control (52.32), Paclobutrazol 1000 ppm (57.12) and Paclobutrazol 500 ppm (61.92).

4.2.12 Effect on yield of panicles per hectare

Data collected on the effect of various plant growth regulators at varied levels on yield of panicles per hectare have been presented in Table 13 and graphically shown in Fig 4.11.

It is clear from the table that, treatments significantly influence the yield of panicles per hectare. Among the various treatments significantly highest yield of panicles per hectare was observed at GA₃ 100 ppm (581110), which was at par with the treatment NAA 100 ppm (516666). Significantly lowest yield of golden rod panicles per hectare was observed with CCC 2000 ppm (202222), which was at par with the treatment CCC 1000 ppm (225884), control (242222), Paclobutrazol 1000 ppm (264477), CCC 500 ppm (265555), Paclobutrazol 500 ppm (286666), NAA 25 ppm (311110) and Paclobutrazol 250 ppm (345925).

4.2.13 Effect of ratoon crop

The data on yield attributes were collected and analysed. The results indicated that, there was no any residual influence of growth regulators sprayed in previous flush because, the data were found non significant as compared to water spray (control).

4.3 ECONOMICS

The economic variability of different plant growth regulators treatments, along with cost of cultivation as was worked out is presented in Table 14. Perusal of the data revealed that, the highest net realization was obtained with GA₃ 100 ppm (236415 Rs. ha⁻¹) followed by NAA 100 ppm (217632 Rs. ha⁻¹) as compared to control (81111 Rs. ha⁻¹). The treatment NAA 100 ppm ranked first with highest C.B.R. value (1 : 6.35), which was followed by GA₃ 100 ppm (1 : 5.37) and NAA 50 ppm (1 : 5.00) as compared to control (1 : 3.03).
Fig 4.11: Effect of growth regulators on yield of panicles per hectare
Table 14: Economics of golden rod as influenced by growth regulators

<table>
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<tr>
<th>Treatments No.</th>
<th>Treatments (ppm)</th>
<th>Yield (No. of panicles ha(^{-1}))</th>
<th>Gross realization (Rs. ha(^{-1}))</th>
<th>Total cost of cultivation (Rs. ha(^{-1}))</th>
<th>Net realization (Rs. ha(^{-1}))</th>
<th>C.B.R.</th>
</tr>
</thead>
<tbody>
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<td>40000</td>
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<td>1 : 4.01</td>
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<td>40175</td>
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<td>40350</td>
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</tr>
<tr>
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<td>NAA 100</td>
<td>516666</td>
<td>258333</td>
<td>40701</td>
<td>217632</td>
<td>1 : 6.35</td>
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<td>T(_8)</td>
<td>CCC 500</td>
<td>265555</td>
<td>132777</td>
<td>50517</td>
<td>82260</td>
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<td>T(_9)</td>
<td>CCC 1000</td>
<td>225884</td>
<td>112942</td>
<td>61034</td>
<td>51908</td>
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<tr>
<td>T(_10)</td>
<td>CCC 2000</td>
<td>202222</td>
<td>101111</td>
<td>82068</td>
<td>19043</td>
<td>1 : 1.23</td>
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<tr>
<td>T(_11)</td>
<td>Paclobutrazol 250</td>
<td>345925</td>
<td>172962</td>
<td>55000</td>
<td>117962</td>
<td>1 : 3.14</td>
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<td>T(_12)</td>
<td>Paclobutrazol 500</td>
<td>286666</td>
<td>143333</td>
<td>70000</td>
<td>73333</td>
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<tr>
<td>T(_13)</td>
<td>Paclobutrazol 1000</td>
<td>264477</td>
<td>132238</td>
<td>100000</td>
<td>32238</td>
<td>1 : 1.32</td>
</tr>
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</table>

Note: Selling price of Golden rod was considered as Rs. 0.50/ spike, according to prevailing market price.
V. DISCUSSION

The present investigation entitled "Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)" was conducted to assess the role of plant growth regulators i.e., different levels of IAA (25, 50, 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and paclobutrazol (250, 500, 1000 ppm) on growth attributes (plant height at full bloom stage, number of suckers per plant at harvesting, fresh and dry weight of plant at the end of the crop), flowering attributes of days taken for flower initiation, length of pedicels, number of inflorescence branches per plant, diameter of the flower stalk, fresh and dry weight of pedicel, yield of pedicels per plant, per pot and per hectare, longevity of inflorescence at site, vivist h/o of pedicel and yield with economics of golden rod. The results of the present experiment as reported in the previous chapter are summarized and discussed herein with assigning suitable reasons and supporting relevant information. The discussion for the sake of convenience has been put under the following heads:

5.1 Effect of Plant Growth Regulators on Growth Attributes
5.2 Effect of Plant Growth Regulators on Flowering Attributes
5.3 Effect of Plant Growth Regulators on Yield
5.4 Economics

5.1 EFFECT OF PLANT GROWTH REGULATORS ON GROWTH ATTRIBUTES

Discussion
The present investigation entitled "Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)," was conducted to assess the role of plant growth regulators i.e. different levels of GA₃ (25, 50 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and paclobutrazol (250, 500 1000 ppm), on growth attributes (plant height at full bloom stage, number of suckers per plant at harvesting, fresh and dry weight of plant at the end of the crop), flowering attributes of days taken for flower initiation, length of panicles, number of inflorescence branches per panicle, diameter of cut flower stalk, fresh and dry weight of panicle, yield of panicles per plant, per plot and per hectare, longevity of inflorescence in situ, vase life of panicle and yield with economics of golden rod. The results of the present experiment as reported in the previous chapter are scrutinized and discussed herewith, assigning suitable reasons and supporting relevant references. The discussion for the sake of convenience has been put under the following heads.

5.1 Effect of Plant Growth Regulators on Growth Attributes
5.2 Effect of Plant Growth Regulators on Flowering Attributes
5.3 Effect of Plant Growth Regulators on Yield
5.4 Economics

5.1 EFFECT OF PLANT GROWTH REGULATORS ON GROWTH ATTRIBUTES

The influence of plant growth regulators on growth attributes of golden rod are discussed below.
5.1.1 Effect on plant height at full bloom stage (cm)

It is clear from the results (Table 4) that, plant height significantly increased due to treatment of GA$_3$ 100 ppm. The increase in plant height by GA$_3$ was due to its effect on stem elongation by increasing cell elongation in sub-apical meristem. The rapid growth is a result of both; more number of cells formed and increased elongation of the individual cells. Increase in plant height as a consequence of GA$_3$ treatments has also been reported by Patil et al., (1996) Pavagadhi (2001), Patel (2004) and Borse (2005) in golden rod, Pandya (2000) in marigold, Rakesh et al., (2003) in chrysanthemum.

NAA 100 ppm treatments increased plant height but, it remained at par with GA$_3$ 100 ppm at harvest. This increase in plant height might be due to the NAA, i.e. auxin, which promoted linear growth by cell elongation along with the longitudinal axis. Cell elongation was occurred with NAA due to uptake of large quantity of water leads to enlargement of vacuole. Similar effect with NAA is also reported by Pavagadhi (2001) and Borse (2005) in golden rod and Pandya (2000) in marigold.

The result also indicated the reduction in plant height by CCC. Although, the reduction in plant height due to CCC was found non significant as compared to control at harvest. However, this reduction in plant height was due to retardation of stem elongation, by preventing cell division in sub-apical meristem and suppression of apical dominance (Weaver, 1972). Moreover the suppression of growth of the main stem by CCC was due to inhibition of sub-apical meristem activity causing reduction in respiration rate and accumulation of photosynthesis (Cathey, 1964). These results are also in agreement with the findings of Patil (1996) in golden rod, Masu (2004) in chrysanthemum, Pandya (2000) and Khandelwal et al., (2003) in marigold, Maurya and Nagda (2002).

The result also indicated the reduction in plant height by paclobutrazol. The reason for reduction in plant height due to paclobutrazol treatments, might be due to the inhibition of gibberellin synthesis, which caused

5.1.2 Effect on number of suckers per plant at harvest

The results (Table 5) showed that, significantly more number of suckers per plant was found in the plants treated with GA$_3$ 100 ppm. This increase in number of suckers per plant might be attributed to the luxuriant vegetative growth of plant, which elaborated more food material and made it available for multiplication of suckers. Similar results were also obtained by Patil (1996), Pavagadhi (2001) and Borse (2005) in golden rod, Nair et al., (2002) in gerbera and Singh et al., (2003) in rose.

NAA at 100 ppm also significantly increased number of suckers per plant in golden rod. This difference was due to positive effect of NAA on growth of golden rod plant. It is similar with the finding of Pavagadhi (2001) and Borse (2005) in golden rod, Ravidas et al., (1992) in gladiolus and Singh et al., (2003).

CCC at 500 ppm also significantly increased number of suckers per plant in golden rod. Similar results were also obtained by Ravidas et al., (1992) in gladiolus. An application of CCC at higher concentrations (500 and 750 ppm), reduced number of suckers per plant. This reduction might be due to inhibitory effect of CCC on growth of plants. It is similar with the findings of Nair et al., (2002) in gerbera.

An application of paclobutrazol reduced number of suckers per plant. This reduction might be due to inhibitory effect of paclobutrazol on growth of plant. Similar result also reported by Muhammad et al., (1997).
5.1.3 Effect on fresh and dry weight of plant (g)

The data shown in (Table 6) revealed that, GA$_3$ 100 ppm and all the other concentrations of GA$_3$ significantly increased the fresh and dry weight of plant. This is because of overall promotion and luxurious vegetative growth (e.g. maximum plant height). So, increase in biomass accumulation in response to GA$_3$ application, also reflected in increase in dry weight of plant. This was also supported by the findings of Patil (1996), Pavagadhi (2001) and Borse (2005) in golden rod and Singh et al., (2003) in tuberose.

The data also indicated (Table 6) that, NAA 100 ppm, also caused significant increase in fresh and dry weight of plant, in golden rod. This was due to its positive effect of NAA on growth of the golden rod plants. This was supported by the findings of Pavagadhi (2001) and Borse (2005) in golden rod.

It is apparent from the results (Table 6) that, all the levels of CCC decreased fresh and dry weight of plants but, it was at par with control. However, this decrease was due to suppressing growth of plant, which inhibited cell division and cell elongation in plant. This result was in agreement with the results obtained by Patil et al., (1996) in golden rod, Girwani et al., (1990) in marigold.

The data also indicated (Table 6) indicate that, each treatment of paclobutrazol 250, 500 and 1000 ppm was found ineffective for fresh weight of plant, whereas, dry weight was significantly increase due to paclobutrazol 250 ppm only. This was supported by the findings of Pill and Gunter (2001).

5.1.4 Effect of ratoon crop

The data collected from ratoon crop for growth attributes was found non significant as compared to water spray i.e. (control). It indicated that, there was no any residual influence of treatment under study.
5.2 EFFECT OF PLANT GROWTH REGULATORS ON FLOWERING ATTRIBUTES

The influence of plant growth substances on flowering characters of golden rod are discussed below.

5.2.1 Effect on number of days taken for flower initiation

The results (Table 7) revealed that, number of days taken for first flowering was significantly minimum with GA$_3$ 100 ppm treatment. This was because; gibberellins are quite effective in reducing juvenile period of plants. At the termination of juvenile phase, the shoot apical meristem is converted to flower primordia instead of producing leaves (Krishnamoorthy, 1975). Increased photosynthesis and respiration with enhanced CO$_2$ fixation in the treated plants are also associated with early flowering (Patel, 1998). Similar results have also been reported by Patil (1996), Pavagadhi (2001) and Borse (2005) in golden rod, Meher et al., (1999) and Poshiya et al., (1995b) in chrysanthemum; Singh et al., (1991) in marigold; Poshiya et al., (1995a) in gaillardia; Nair et al., (2002) in gerbera; Maurya and Nagda (2002) in gladiolus and Singh (1999) in tuberose.

It is clear from the data that, NAA 100 ppm took minimum days for flower initiation as compared to control. Similar result has been reported by Pavagadhi (2001) and Borse (2005) in golden rod, Maurya and Nagda (2002) in gladiolus.

Flowering took less number of days due to different CCC treatments as compared to control. However, this early flowering might be due to its action as an anti-gibberellin (Shrivastava, 1994), which is quite effective in reducing juvenile period and is necessary to terminate the vegetative phase. Similar results have also been reported by Patil et al., (1996) in golden rod and Nair et al., (2002) in gerbera.

Treatments of Paclobutrazol at 250, 500 and 1000 ppm reduced the number of days for flower initiation in golden rod as compared to control. This result is agreement with those reported by Parmar (2004).
Plate - IV: Control (distilled water) on growth and flowering of golden rod

Plate - V: Effect of GA₃ at 100 ppm on growth and flowering of golden rod

Plate - VI: Effect of NAA at 100 ppm on growth and flowering of golden rod
**5.2.2 Effect of growth regulators on length of panicle (cm)**

The results presented in (Table 8) clearly showed that, there was significant increase in length of panicle by GA₃ 100 ppm treatment. This significant increase in the length was due to the cell elongation and cell division or both. These results are in accordance with the findings of Patil (1996), Pavagadhi (2001) and Borse (2005) in golden rod, Dutta et al., (1993 and 1995), Kumar and Ugherja (1998), Meher et al., (1999) in chrysanthemum, Maurya and Nagda (2002) in gladiolus, Singh et al., (2003) in tuberose; Nair et al., (2002) in gerbera.

Application of different NAA treatments increased the length of panicle. This increase might be due to increased cell division under the influence of auxin. Similar results have been reported by Pavagadhi (2001) and Borse (2005) in golden rod, Maurya and Nagda (2002) in gladiolus and Singh et al., (2003) in tuberose.

It was observed that, 1000 and 2000 ppm of CCC reduced the length of panicle although, the reduction in length of panicle due to CCC was found non significant as compared to control except 500 ppm. However, this reduction in length of panicle was due to suppression or inhibition of cell division and cell elongation due to CCC. These results are in accordance with the findings of Patil et al., (1996) and Patel (2004) in golden rod, Dutta et al., (1993 and 1995) in chrysanthemum; Nair et al., (2002) in gerbera; Ravidas et al., (1992) and Maurya and Nagda (2002) in gladiolus.

It is clear from the (Table 8) that, paclobutrazol treatment reduced the length of panicle of golden rod, but it was found at par with the control. Reduction in length of panicle might be due to the growth retarding property of paclobutrazol, which ultimately suppressed or inhibited cell division and cell elongation in panicle, which reduce length of panicle. Corroborating results due to paclobutrazol have been recorded by Patil et al., (1996) in golden rod, Singh (2001) in chrysanthemum and Mann (2003) in marigold.
5.2.3 Effect on number of inflorescence branches per panicle

The data presented (Table 9) revealed that, significantly higher number of inflorescence branches per panicle was found at GA$_3$ 100 ppm. This increase in number of inflorescence branches per panicle could be attributed to the increase in photosynthesis and respiration with enhanced carbohydrate fixation in GA$_3$ treated plants. These results are in accordance with the findings of Patil (1996), Pavagadhi (2001) and Borse (2005) in golden rod, Maurya and Nagda (2002) in gladiolus and Singh et al., (1999) in tuberose.

NAA at 100 ppm increased the number of inflorescence branches per panicle. This increase might be due to increased photosynthesis efficiency with enhanced carbohydrate fixation in NAA treated plants. These results were in accordance with findings of Pavagadhi (2001), Borse (2005) in golden rod and Maurya and Nagda (2002) in gladiolus.

Reduction in number of inflorescence branches per panicle was found with different CCC treatments, which was at par with control. This was due to inhibitory effect of CCC on golden rod plant. Similar results have also been reported previously by, Patil et al., (1996), Borse (2005) in golden rod, Ravidas et al., (1992) and Maurya and Nagda (2002) in gladiolus.

The treatment of paclobutrazol was found ineffective for the number for inflorescence branches per panicle.

5.2.4 Effect on diameter of cut flower stalk

The results of present study revealed that, response of plant growth regulators on diameter of flower stalk differed significantly (Table 10).

Among all the treatments highest diameter of cut flower stalk (6.42 cm) was observed due to GA$_3$ 100 ppm. This increase in the diameter was due to increase in the cell division and cell expansion or both. Thus, the higher concentration of GA$_3$ is more effective in multiplication of cell as well as enlargement of young tissues. Similar, results were also reported by Patil (1996) and Pavagadhi (2001) in golden rod, Meher et al., (1999) in chrysanthemum, Kraguzel et al., (1999) in gladiolus.
NAA at 100 ppm significantly increased the diameter of cut flower stalk (4.63 cm) as compared to control in golden rod. The possible explained for increase in diameter of cut flower stalk might be due to its major role in influencing the carbohydrate supply and at the same time its transformation in the plants. Similar, results were also reported by Pavagadhi (2001) in golden rod.

Application of CCC at 500, 1000 and 2000 ppm and paclobutrazol at 250, 500 and 1000 ppm was found non significant effect on diameter of cut flower stalk.

Effect of all the treatments of paclobutrazol remained at par with water spray i.e. (control). It means paclobutrazol had no any effect on diameter of cut flower stalk.

5.2.5 Effect on longevity of panicle in situ (days)

The result presented in (Table 11) clearly showed that the highest longevity of panicle in situ was significantly increased by treatment CCC 500 ppm as compared to control. However, each treatment of CCC significantly increased the longevity of panicle in situ. This was might be due to cycocel, which is a growth retardant, and it might have checked the metabolic processes, which have reduced the action of senescence resulting in increase longevity of panicle in situ. These findings were in close conformity with Maurya and Nagda (2002) in gladiolus, Patil et al., (1996) and Borse (2005) in golden rod.

Also, GA$_3$ at 100 ppm significantly increased the longevity of panicle in situ as compared to control. This was because of high protoplasmic and moisture content of panicle with increased concentration of GA$_3$. Similar results have also been reported by Pavagadhi (2001), Borse (2005) in golden rod and Kumar and Ugherja (1998) in chrysanthemum.

NAA at 100 ppm significantly increased the longevity of panicle in situ as compared to control. Similar results have also been reported by

CCC at 500 ppm significantly increased the longevity of panicle *in situ* as compared to control. However, further increased concentration of CCC at 1000 and 2000 ppm also decreased the longevity of panicle and found at par with control. These results are agreement with the findings of Patil *et al.*, (1996) and Borse (2005) in golden rod.

Paclobutrazol 250, 500 and 1000 ppm treatments reduced the longevity of panicle of golden rod as compared to control. This negative effect of paclobutrazol on longevity of panicle observed in the present finding is agreement with the findings of Hwang *et al.*, (1986) in gladiolus and Parmar (2004) in chrysanthemum.

5.2.6 Effect on vase life of panicle (days)

Data presented in (Table 11) revealed that, vase life of flower was considerably influenced by all the plant growth regulators treatments. The results clearly revealed that, maximum vase life of golden rod flowers was observed with CCC treatments. Restricted respiration due to inhibitory action of retardant might have increased vase life of golden rod. Similar findings were also obtained by Patil *et al.*, (1996) and Borse (2005) in golden rod, Pandya (2000) in marigold and Makwana (1999) in gaillardia.


NAA 100 ppm treatment had increase vase life of golden rod over control. The positive effect of NAA on extending the vase life observed in
Plate VII: Effect of treatment in vase life
the present study are in conformity with the findings of Pavagadhi (2001) and Borse (2005) in golden rod.

All the treatment of paclobutrazol increased vase life of panicle of golden rod as compared to control. This positive effect of paclobutrazol on vase life observed in the present finding is not in agreement with the findings of Hwang et al., (1986) in gladiolus and Parmar (2004) in chrysanthemum.

5.2.7  
**Fresh weight and dry weight of panicle (g)**

The result presented in (Table 12) showed, significantly more fresh and dry weight of panicle due to GA₃ treatments. The increase in fresh weight and dry weight of panicle is attribute due to the increased panicle length and accumulation of more food material. Similar results have also been reported by Pavagadhi (2001), in golden rod and Talukdar and Paswan (1994 and 1996) in chrysanthemum.

NAA 100 ppm treatment increased fresh and dry weight of panicle of golden rod over control. The positive effect of NAA on fresh and dry weight of panicle observed in the present study are in agreement with the findings of Pavagadhi (2001), Borse (2005) and Patel (2004) in golden rod.

The reduction in fresh and dry weight of panicle was recorded due to CCC treatments, which remained at par with control. This reduction is due to reduction in growth of the plants due to its inhibitory effect. Similar result has also been reported by Mohandas (1986) in chrysanthemum.

It is clear from the data (Table 12) that the paclobutrazol could not found beneficial in increasing fresh and dry weight of panicle. This reduction was due to reduction in fresh and dry weight of plant. These findings are agreement with those reported by Yawale et al., (1998a) in chrysanthemum.

5.2.8  
**Effect of ratoon crop**

The data collected from ratoon crop for flowering attributes was found non significant as compared to water spray i.e. (control). It indicated that, there was no any residual influence of treatment under study.
5.3 EFFECT OF PLANT GROWTH REGULATORS ON YIELD

5.3.1 Yield of panicles per plant, per plot and per hectare

The data presented in the (Table 13) reflected the fact that, the highest yield of panicles per plant was found with the treatment GA\textsubscript{3} at 100 ppm. This increased yield of panicles was due to the availability of desirable food materials and more carbohydrate supply, which ultimately effects on flower production. Similar results have also been reported by Pavagadhi (2001) and Borse (2005) in golden rod, Rakesh \textit{et al.}, (2003) in chrysanthemum, Pandya (2000) in marigold and Maurya and Nagda (2002) in gladiolus.

Significantly increased yield over control was also observed with NAA 100 ppm. This increase is due to the auxin, which stimulated availability of food materials and carbohydrate supply, which ultimately effects the flower production. Such response was due to NAA application also been reported previously by Pavagadhi (2001), Borse (2005) in golden rod, Dutta \textit{et al.}, (1993 and 1995), Sharma \textit{et al.}, (1995), Kumar and Ugherja (1998) in chrysanthemum. Pandya (2000) in marigold and Maurya and Nagda (2002) in gladiolus.

It was observed that, each levels of CCC reduced the yield of panicles per plant, per plot and per hectare as compared to control. This reduction might be due to its inhibitory effect on cell division and cell elongation, and thus reduced the number of panicles. Similar results have also been reported by Patel (2004), Borse (2005) in golden rod, Pandya (2000) in marigold and Masu (2004) in chrysanthemum.

Results (Table 13) showed that each levels of paclobutrazol increased the yield per plant, per plot and per hectare as compared to control. This increase in yield of panicles may be due to the availability of desirable food materials and more carbohydrate supply, which ultimately effects on flower production. Similar results have also been reported by Mann (2004) and Parmar (2004) in chrysanthemum.
5.3.2 Effect of ratoon crop

The data collected from ratoon crop for yield was found non significant as compared to water spray i.e. (control). It indicated that, there was no any residual influence of treatment under study.

5.4 ECONOMICS

The economics of crop production worked out for each treatment (Table 14) showed that, the highest net realization was found with GA₃ 100 ppm (236415 Rs. ha⁻¹) due to higher yield, which lead to higher income. However, the highest C.B.R value was recorded with NAA 100 ppm (1 : 6.35) followed by GA₃ 100 ppm (1 : 5.37), NAA 50 ppm (1 : 5.00) because of the lowest cost of cultivation as compared to all other treatments. The lowest net realization and C.B.R value was recorded with CCC 2000 (1 : 1.23) followed by Paclobutrazol 1000 ppm (1 : 1.32) due to the highest cost and lowest yield as compared to all other treatments and control.
Summary and Conclusion

The present investigation entitled "Influence of growth regulators on growth and flowering of goldenrod (Solidago virgaurea L.)" was conducted at Horticultural Instructional Farm, Department of Horticulture, College of Agriculture, Jauagadh Agricultural University, Jauagadh, during July 2005 to November 2005 (first flush) and January 2006 (second flush) with data from November 2005 to March 2006. The treatments comprised of four different growth regulators viz. GA₃ (25, 50 and 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and Potassium nitrate (250, 500 and 1000 ppm) and Distilled water spray (control). The experiment was laid out in a Randomised Block Design with thirteen treatments, replicated twice.

The salient features of the experimental findings obtained are being summarized as under:

1. Maximum plant height at full bloom stage was recorded with GA₃ 100 ppm (125.80 cm), followed by NAA 100 ppm (122.59 cm), while minimum plant height was found by water spray i.e., control (100.43 cm).

2. The highest number of suckers per plant was obtained with GA₃ 100 ppm (7.86), followed by NAA 100 ppm (7.04), while lowest number of suckers obtained with potassium nitrate 1000 ppm (4.53) and water spray i.e., control (4.30).

3. Highest fresh and dry weight of plants were obtained with GA₃ 100 ppm (258.49 and 91.45 g, respectively), followed by NAA 100 ppm (249.74 g and 81.88 g), respectively.

Minimum number of days for first flower initiation was found by GA₃ 100 ppm (60.04 days), followed by NAA 100 ppm (53.17 days) and CCC 300 ppm (65.24 days), while maximum number...
VI. SUMMARY AND CONCLUSION

6.1 SUMMARY

The present investigation entitled “Influence of growth regulators on growth and flowering of golden rod (Solidago canadensis L.)” was conducted at Horticultural Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agriculture University, Junagadh, during July 2005 to November 2005 (first flush) and ratoon crop (second flush) was taken from November 2005 to March 2006. The treatments comprised of four different growth regulators viz. GA$_3$ (25, 50 and 100 ppm), NAA (25, 50 and 100 ppm), CCC (500, 1000 and 2000 ppm) and Paclobutrazol (250, 500 and 1000 ppm) and Distilled water spray (control). The experiment was laid out in a Randomized Block Design with thirteen treatments, replicated thrice.

The salient features of the experimental findings obtained are being summarized as under:

1. Maximum plant height at full bloom stage was recorded with GA$_3$ 100 ppm (125.00 cm), followed by NAA 100 ppm (122.80 cm), while minimum plant height was found by water spray i.e. control (100.83 cm).

2. The highest number of suckers per plant was obtained with GA$_3$ 100 ppm (7.86), followed by NAA 100 ppm (7.04), while lowest number of suckers obtained with paclobutrazol 1000 ppm (4.55) and water spray i.e. control (4.80).

3. Highest fresh and dry weight of plants were obtained with GA$_3$ 100 ppm (258.48 and 91.45 g, respectively), followed by NAA 100 ppm (249.74 g and 81.88 g, respectively), while lowest was obtained under water spray i.e. control (188.59 and 50.66 g, respectively).

4. Minimum number of days for first flower initiation was found by GA$_3$ 100 ppm (60.04 days), followed by NAA 100 ppm (65.17 days) and CCC 500 ppm (65.24 days), while maximum number
516666.15, respectively), as compared to water spray i.e. control (2.18, 52.32 and 242222.05, respectively).

12. The highest net realization was recorded with GA$_3$ 100 ppm (236415 Rs. ha$^{-1}$), followed by NAA 100 ppm (217632 Rs. ha$^{-1}$) as compared to water spray i.e. control (81111 Rs. ha$^{-1}$), while highest C.B.R. value was found by NAA 100 ppm (1 : 6.35) and GA$_3$ 100 ppm (1 : 5.37) as compared to water spray i.e. control (1 : 3.03).

13. There was not any residual influence of treatment in the ratoon crop.

CONCLUSION

From the foregoing discussion, it can be concluded that the foliar sprays of GA$_3$ 100 ppm at 30 and 45 days, influenced the vegetative growth, flowering, flower yield and longevity in situ of golden rod plant. The application of NAA at varied levels caused marked effect on different plant attributes. However, economic point of view, NAA 100 ppm gave the highest cost benefit ratio due to low cost of cultivation. CCC at lower level (500 ppm) improved longevity in situ and vase life of flower but not found effective for growth, flowering and yield of golden rod. Foliar spray of paclobutrazol did not influence the vegetative growth, flowering, flower yield and longevity in situ of golden rod. The ratoon crop was not influenced by the application of different plant growth regulators.
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* Original not seen.
Appendix I: Cost of cultivation of golden rod required for one hectare.

<table>
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<th>Sr. No.</th>
<th>Particulars</th>
<th>Cost (Rs. / ha)</th>
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<td>1</td>
<td>Cost of suckers Rs. 50 / 100 suckers</td>
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<td>2</td>
<td>Ploughing and harrowing Rs. 3000 / ha</td>
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<tr>
<td>3</td>
<td>Application of FYM and fertilizer RDF</td>
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<tr>
<td>4</td>
<td>Propagation of 0.5 N bales</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>Preparation of specific shoots</td>
<td>180</td>
</tr>
<tr>
<td>6</td>
<td>Transplanting of suckers and field tilling</td>
<td>500</td>
</tr>
<tr>
<td>7</td>
<td>Three hand weeding</td>
<td>1,000</td>
</tr>
<tr>
<td>8</td>
<td>Plant protection</td>
<td>578</td>
</tr>
<tr>
<td>9</td>
<td>Irrigation</td>
<td>2,300</td>
</tr>
<tr>
<td>10</td>
<td>Harvesting and transport</td>
<td>6,160</td>
</tr>
<tr>
<td>11</td>
<td>Picking charges</td>
<td>200</td>
</tr>
<tr>
<td>12</td>
<td>Land revenue</td>
<td>750</td>
</tr>
<tr>
<td>13</td>
<td>Subsidies speak 30 % of total field</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40,000</td>
</tr>
</tbody>
</table>

Appendix
Appendix I: Cost of cultivation of golden rod required for one hectare.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Cost (Rs. / ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cost of suckers Rs. 20 / 100 suckers</td>
<td>22,222</td>
</tr>
<tr>
<td>2.</td>
<td>Ploughing and harrowing Rs. 3000 / ha</td>
<td>3,000</td>
</tr>
<tr>
<td>3.</td>
<td>Application of FYM and fertilizer RDF</td>
<td>1,000</td>
</tr>
<tr>
<td>4.</td>
<td>Preparation of field layout</td>
<td>300</td>
</tr>
<tr>
<td>5.</td>
<td>Preparation of irrigation channel</td>
<td>100</td>
</tr>
<tr>
<td>6.</td>
<td>Transplanting of suckers and gap filling</td>
<td>500</td>
</tr>
<tr>
<td>7.</td>
<td>Three hand weeding</td>
<td>1,000</td>
</tr>
<tr>
<td>8.</td>
<td>Plant protection</td>
<td>578</td>
</tr>
<tr>
<td>9.</td>
<td>Irrigation</td>
<td>2,500</td>
</tr>
<tr>
<td>10.</td>
<td>Harvesting and transport</td>
<td>4,500</td>
</tr>
<tr>
<td>11.</td>
<td>Packing changes</td>
<td>200</td>
</tr>
<tr>
<td>12.</td>
<td>Land revenue</td>
<td>100</td>
</tr>
<tr>
<td>13.</td>
<td>Supervision change 10 % of total field cost</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td>[A] Total</td>
<td>40,000</td>
</tr>
</tbody>
</table>
## Appendix II: Cost of growth regulators required for one hectare.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Cost (Rs. / ha) for two spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water spray (Control)</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>Gibberellic acid (GA₃ 25 ppm)</td>
<td>3535</td>
</tr>
<tr>
<td>3.</td>
<td>Gibberellic acid (GA₃ 50 ppm)</td>
<td>7070</td>
</tr>
<tr>
<td>4.</td>
<td>Gibberellic acid (GA₃ 100 ppm)</td>
<td>14140</td>
</tr>
<tr>
<td>5.</td>
<td>Naphthalene acetic acid (NAA 25 ppm)</td>
<td>175</td>
</tr>
<tr>
<td>6.</td>
<td>Naphthalene acetic acid (NAA 50 ppm)</td>
<td>350</td>
</tr>
<tr>
<td>7.</td>
<td>Naphthalene acetic acid (NAA 100 ppm)</td>
<td>701</td>
</tr>
<tr>
<td>8.</td>
<td>Cycocel (CCC 500 ppm)</td>
<td>10517</td>
</tr>
<tr>
<td>9.</td>
<td>Cycocel (CCC 1000 ppm)</td>
<td>21034</td>
</tr>
<tr>
<td>10.</td>
<td>Cycocel (CCC 2000 ppm)</td>
<td>42068</td>
</tr>
<tr>
<td>11.</td>
<td>Paclobutrazol 250 ppm</td>
<td>15000</td>
</tr>
<tr>
<td>12.</td>
<td>Paclobutrazol 500 ppm</td>
<td>30000</td>
</tr>
<tr>
<td>13.</td>
<td>Paclobutrazol 1000 ppm</td>
<td>60000</td>
</tr>
</tbody>
</table>