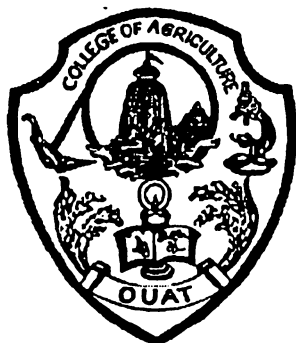


**EFFECT OF PLANTING DATE AND SPACING ON  
GROWTH AND FLOWER YIELD OF GOLDEN ROD  
(*Solidago canadensis* L.)**

**A THESIS SUBMITTED TO  
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY  
BHUBANESWAR  
IN PARTIAL FULFILMENT OF REQUIREMENTS  
FOR THE DEGREE OF  
MASTER OF SCIENCE IN AGRICULTURE  
(FLORICULTURE AND LANDSCAPING)**

By

Pranatirani Pradhan



**DEPARTMENT OF FLORICULTURE AND LANDSCAPING  
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ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY  
BHUBANESWAR, ODISHA  
2013**

**THESIS ADVISOR:**

**Dr. C.R. MOHANTY**



*Dedicated to my  
Beloved  
Maa & Bapa*





DEPARTMENT OF FLORICULTURE AND LANDSCAPING  
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Dated: 29/7/2013


**CERTIFICATE - I**

This is to certify that the thesis entitled “EFFECT OF PLANTING DATE AND SPAING ON GROWTH AND FLOWER YIELD OF GOLDEN ROD (*Solidago canadensis* L.)” submitted for the award of Degree of MASTER OF SCIENCE (AGRICULTURE) in the subject of FLORICULTURE AND LANDSCAPING of the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record of *bona fide* and original research work carried out by PRANATIRANI PRADHAN under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation has been fully acknowledged.

Place: Bhubaneswar

Date: 29/7/2013

  
(Dr. C.R. Mohanty)  
Chairman,  
Advisory committee

## CERTIFICATE - II

This is to certify that the thesis entitled “EFFECT OF PLANTING DATE AND SPACING ON GROWTH AND FLOWER YIELD OF GOLDEN ROD (*Solidago canadensis* L.)” submitted by PRANATIRANI PRADHAN to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the award of Degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject **FLORICULTURE AND LANDSCAPING** has been approved by the Student’s Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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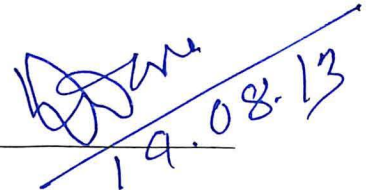
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Date: 29/07/2013

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## **ABSTRACT**

A field trial was conducted in the Department of Floriculture & Landscaping, College of Agriculture, OUAT, Bhubaneswar during the period from August, 2011 to May, 2012 to study the effect of planting date and spacing on growth and flower yield of golden rod (*Solidago canadensis* L.) cv. Local yellow. The experiment consisted of three planting dates (D<sub>1</sub>- 20<sup>th</sup> August, D<sub>2</sub>- 20<sup>th</sup> September and D<sub>3</sub>- 20<sup>th</sup> October) and four spacings (S<sub>1</sub>- 40x30 cm, S<sub>2</sub>- 40x40 cm, S<sub>3</sub>- 60x30 cm and S<sub>4</sub>- 60x40 cm). It was laid out in Randomized block design (RBD) with factorial concept having three replications. The result indicated significantly higher plant height, number of suckers, number of flower panicle, length of panicle and rachis as well as number of primary branches per panicle under September planting but initiation of flower panicle as well as first flowering were earliest under August planting. So far as flower yield was concerned, significantly higher yield of 169455.9 panicle per ha was produced under September planting while the lowest (116081.8 nos. per ha) was recorded under August planting. Among various spacings tried, plants under closest spacing of 40x30 cm (S<sub>1</sub>) exhibited significantly taller plants with earliest emergence of flower panicle and first flowering. It also recorded maximum panicle and rachis length. However, number of leaves, number of panicles, number and spread of primary branches of panicle as well as longevity of flower panicle under field condition were higher under widest spacing of 60x40 cm (S<sub>4</sub>). Maximum yield of 169730.2 panicles per ha was produced with closest spacing of 40x30 cm while the lowest yield (145508.9 nos. per ha) was recorded under widest spacing of 60x40 cm. However, cost : benefit ratio was observed to be higher (2.49) under widest spacing as compared to the closest spacing (2.37).

The interaction of September planting with closest spacing (D<sub>2</sub>S<sub>1</sub>) exhibited longer panicle and rachis, while August planting with closest spacing (D<sub>1</sub>S<sub>1</sub>) recorded earliest initiation of flower panicle and production of first flower. On the other hand, greater plant height with more number of leaves per clump was recorded under September planting with widest spacing (D<sub>2</sub>S<sub>4</sub>).

So based on the overall performance of the plants under different planting dates and spacings, it can be concluded that September planting with 60x40 cm spacing could be taken up for commercial cultivation of golden rod cv. Local yellow in and around Bhubaneswar, which could give a cost : benefit ratio of 2.49.

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## ABBREVIATIONS

%	:	Percentage
@	:	At the rate of
BSH	:	Bright sunshine hours
CD	:	Critical difference
cm.	:	Centimeter
cv.	:	Cultivar
DAT	:	Days after transplanting
<i>et al.</i>	:	And others
etc.	:	Etcetera
Fig.	:	Figure
FYM	:	Farm yard manure
Ha	:	Hectare
i.e.	:	That is
kg	:	Kilogram
km	:	Kilometer
m.	:	Meter
Max.	:	Maximum
Min.	:	Minimum
mm.	:	Millimeter
MSL	:	Mean sea level
nos.	:	Numbers
q	:	Quintal
RH	:	Relative Humidity
SE(m)±	:	Standard error of mean
T	:	Tonn
var.	:	Variety
viz.	:	Namely

CHAPTER - I  
Introduction



## INTRODUCTION

Golden rod, as the name indicates, is a plant with bright golden yellow flowers. It belongs to genus *Solidago* which comprises of about 100 species of flowering plants in the family Asteraceae. Golden rods are herbaceous perennial species found in the meadows and pastures, along roads, ditches and waste areas in North America. There are also a few species native to Mexico, South America, and Eurasia. Some American species have also been introduced into Europe and other parts of the world.

Golden rod is a common wild flower, sometimes called Aaron's rod. The name *solidago* was given to the plant by the botanist Linnaeus. It comes from two Latin words “*solida*,” meaning “whole” and “*ago*” meaning “to make”, and refers to this plant’s role as a natural pharmaceutical. The Italians know the herb as “*Solidago*” as do the Spanish, though they also call the herb “*Vara de oro*.” In French, golden rod translates to “*Verge d’or*” and in German to “*Goldrute*.” In America, golden rod also goes by the general names of woundwort and Aaron’s rod, though each species has its own common name(s).

Golden rods are hardy perennial herbs grown in almost all climate and soil but prefer a sunny location. Few species like *Solidago canadensis*, *Solidago bicolor*, *Solidago virgaurea*, *Solidago nemoralis* are grown as attractive garden plants in beds, borders or rock gardens and produce large panicles of golden yellow flowers for several months in a year. Among various species grown in India, *Solidago canadensis* is the most popular one which is not only grown as garden plant but also cultivated on a commercial scale for production of attractive cut flowers. Its panicles are used as fillers during bouquet preparation, for table arrangement and also for decoration.

Golden rod has held a significant place in American history. It is the state flower of the U.S. states of Kentucky and Nebraska. It used to be the state

flower of Alabama, but was later rejected in favour of the camellia. Golden rod was recently named as the state wildflower for South Carolina.

Golden rod is used as an ornamental plant in gardens, beds and borders, and as potted plant. It combines gracefully with other ornamentals like asters, sedum, mums, salvia, boltonia, liatris and ornamental grasses. Both fresh and dry flowers of golden rod are used as cut flower. Golden rod has several uses besides as an ornamental plant such as therapeutic and industrial use. It has got several therapeutic uses. Traditionally, it is used to treat tuberculosis, diabetes, enlargement of the liver, gout, hemorrhoids, internal bleeding, asthma and arthritis. Topically, golden rod is used in folk medicine to treat inflammation of the mouth and throat, as well as slow healing wounds. It also relieves muscle spasms, fight infections, and lower blood pressure. It is documented as having been used as an astringent, carminative, diaphoretic, diuretic, and stimulant, as well as to treat warts, tumors and cancers. The pharmacological activity of golden rod is due to the presence of leiocarposide, flavonoids, saponins and essential oil. Industrially, dye is extracted from golden rod which is used to dye homespun cotton, wool, linen, and silk. Depending on how the flower head is prepared; it produces either a golden yellow or dark olive-green color. It is also a source of nectar, and honey produced from this is generally dark in colour. Fibre extracted from this plant is used to make ropes. It is a source of rubber and also used in making fertilizer.

Although golden rod is grown in several parts of the country, it is least exploited commercially. It is a newly introduced crop which is not popular yet but holds tremendous potential as a cut flower. It has recently been included in National Horticulture Mission (NHM) programme in the state of Odisha. Agro-climatic condition of the state is quite favourable and there is also good scope for commercial cultivation of this flower crop, but standardization of horticultural practices has not been done so far under local agro-climatic condition for its profitable cultivation. So, standard horticultural practices should be available to the flower growers of the state to increase area and

production under this crop. Since, this is a new crop recently introduced in the state, there is need to standardize various aspects of production technology under local agro climatic condition for the benefit of the farmers.

Among various factors influencing growth and flowering, planting date and spacing adopted assume great significance which influence plant growth and yield to a greater extent in various flower crops grown commercially and golden rod is not an exception. However, very little information is available on these aspects of crop production in this least exploited crop.

Hence, considering its importance as a commercial flower crop and keeping all the above stated facts in view, the present investigation entitled “Effect of planting date and spacing on growth and flower yield of golden rod (*Solidago canadensis* L.)” was undertaken with the following objectives.

- i) To study the effect of planting dates on growth and yield of flowers.
- ii) To study the effect of different spacings on growth and yield flowers and;
- iii) To find out the ideal combination of planting date and spacing for recommendation to the flower growers for commercial flower production in and around Bhubaneswar.

CHAPTER - II

Review of Literature



## REVIEW OF LITERATURE

In commercial cultivation of golden rod as a cut flower, among various factors influencing growth and flowering, planting date and spacing adopted assume great significance which influence plant growth and yield of flowers to a greater extent. However, very little information is available on these aspects of crop production in golden rod. Therefore, an attempt has been made to review the available literature pertaining to present study on golden rod as well as other flower crops such as chrysanthemum, marigold, gaillardia, fritillaria, carnation, china aster, dahlia, coreopsis, cosmos, gerbera, gladiolus, ornamental sunflower, ornamental onion, calendula, lachenalia, tuberose, spiderlily, narcissus and liliun which are presented in this chapter.

### 2.1 Effect of planting date:

#### 2.1.1 Effect of planting date on growth and flowering of golden rod

Werner (1989) conducted a field experiment to find out the influence of genotype and environment on flowering time of golden rod (*Solidago canadensis*). From the experiment it was concluded that the differences in flowering time among the clones within a golden rod population was largely determined by genetic variation rather than by environmental factors.

Barad *et al.* (2011) in an investigation on golden rod found that out of two cuttings (main and ratoon), main harvest had pronounced effect on vegetative parameters during summer and rainy plantings except number of suckers and fresh weight of plant, which was higher during both plantings. Earliest flowering was observed in ratoon harvesting during summer planting.

#### 2.1.2 Effect of planting date on growth and flowering of other flowers

An investigation was carried out to study the effect of different sowing times on performance of dahlia in Pakistan (Afzal *et al.*, 2000). The result

showed that for different characters such as seed germination time, plant height, days to flower, blooming period, flower size and seed yield, the best sowing time was 25<sup>th</sup> of September.

A study on the effect of planting time on vegetative growth of *Coreopsis* (Kumar and Kaur, 2001) revealed that the tallest plant with widest spread were produced from early planting as compared to lowest from late planting. The number of branches produced by the plant and seed yield were also high in case of early planting as compared to late planting.

Dubey *et al.* (2002) conducted an experiment to study the effect of planting time on growth, flowering and seed production on cosmos. The study concluded that among four planting dates (viz., 15<sup>th</sup> May, 15<sup>th</sup> June, 15<sup>th</sup> July and 15<sup>th</sup> August). 15<sup>th</sup> August was found to be the best over May and July plantings for plant height, plant spread, number of branches per plant, duration of flowering, number of flowers per plant, number of heads per plant, seed yield, percentage of germination and viability.

In an experiment on effect of planting date on growth and flowering of gerbera cv. Sath Baba (Manjusha and Patil, 2002), it was found that among the two dates of planting (June and July), July planting resulted in more number of leaves, leaf area, horizontal spread and number of flowers as compared to June planting.

Tomar (2002) conducted an experiment on African marigold cv. Pusa Narangi Gainda to study the effect of planting dates on seed yield with three planting dates (2<sup>nd</sup> week of September, October and November). The study revealed that maximum seed yield with high germination percentage could be achieved by planting the seed crop in 2<sup>nd</sup> week of November.

In a similar experiment on African marigold cv. Pusa Narangi Gainda, Rao and Reddy (2002) found that June planting was the best for maximum flower and seed yield whereas maximum flower bud initiation was recorded

during September and October months. On the other hand number of days required for 1<sup>st</sup> flowering was reduced from August to February. In case of March planting, flowering was delayed while flower induction was low in July planted crop.

According to Sharma and Talukdar (2002), gladiolus cv. Sylvia planted on November 5<sup>th</sup> recorded maximum number of sprouts with tallest plants, largest leaves, maximum number of spikes and longest rachis.

An experiment on ornamental sunflower var. Sunrich Orange was conducted by Singh *et al.* (2002) to study the effect of different sowing dates. It was observed that seeds sown on October 15<sup>th</sup> gave the best performance in terms of plant height, stem diameter, number of leaves, size of flower and longest vase life. Highest size of leaves was obtained from sowing of 17<sup>th</sup> September. The minimum height of plants with lowest number of leaves and longest harvesting period was recorded from plants raised from December 10<sup>th</sup> sowing.

Mathew and Shepherd (2002) studied the effect of planting date on African marigold. Planting was done on six dates (September 5<sup>th</sup>, September 20<sup>th</sup>, October 5<sup>th</sup>, October 20<sup>th</sup>, November 5<sup>th</sup> and November 20<sup>th</sup>) out of which October 5<sup>th</sup> showed overall superiority over other planting dates.

In a similar study on gladiolus cv. American Beauty (Shiva and Dadlani, 2002), it was found that out of five dates of planting viz., November 10<sup>th</sup>, November 20<sup>th</sup>, December 1<sup>st</sup>, December 15<sup>th</sup> and December 30<sup>th</sup>, November 10<sup>th</sup> planting proved to be the best with respect to vegetative growth, flowering, corm and cormel production both inside and outside the polyhouse conditions.

The effect of planting date on growth and flowering of carnation cv. Impala was studied by Verma and Sharma (2002). They reported that maximum plant height and stem length were recorded in October planted crop whereas the values were minimum for June planting. Earliest flower bud

initiation and flowering was observed in February planted crop, while maximum flower size in June planting, minimum disease incidence in October planting, minimum insect-pest attack in June planting and maximum number of flowers per plant as well as yield per square meter were obtained from October planted crop.

Basavarajeshwari *et al.* (2003) studied the effect of planting time on growth and flower yield in gaillardia. Planting was done in each of the 12 months of calendar year. Growth parameters viz., plant height, number of branches, number of leaves, dry weight of plant and leaf characteristics were highest in January planting followed by December planting. Flower initiation and 50% flowering were early in January planting followed by December planting. Similarly, flower quality in terms of flower diameter, number of flowers per plant and flower yield was also maximum in January planted crop followed by December planting.

Hugar *et al.* (2003) conducted a study on the effects of different dates of planting on growth and flower yield three aster varieties (Kamini, Aster Purple and Aster White). It was observed that among four planting dates (2<sup>nd</sup> week of August, 1<sup>st</sup> week of September, 4<sup>th</sup> week of September and 3<sup>rd</sup> week of October), plants grown during 2<sup>nd</sup> week of August had maximum flower yield (5.22 t/ha) followed by those grown during 4<sup>th</sup> week of September (4.96 t/ha).

According to Grawal *et al.* (2004), chrysanthemum cv. Flirt planted in 1<sup>st</sup> week of July was at par with August planting (2<sup>nd</sup> week) in terms of number of flowers per plant which recorded 9.05 and 8.91 flowers respectively.

An investigation on growth and flowering of French marigold cv. Selection-2 (Raju *et al.*, 2006) showed that among different planting months viz., May, June, July and August, July planting resulted in maximum flower yield per plant while August planting had maximum diameter and weight of

individual flower. It was concluded that July planting was the best for seed production under Delhi condition.

An investigation carried out on African marigold by Sreekanth *et al.* (2006) at ANGRAU, Hyderabad during Rabi season of 2004-05 concluded that among three planting dates viz., October, November and December, October planting recorded maximum diameter and yield of flowers per plant as well as per hectare.

Anjum *et al.* (2007) studied the effect of various sucker sizes and planting time on flowering and vase life of chrysanthemum. Small and large sized suckers (with a difference of at least 5 cm in height) were planted on four different planting dates i.e. 18<sup>th</sup> February, 18<sup>th</sup> April, 17<sup>th</sup> June and 16<sup>th</sup> August. It was observed that earliest planting took more time to initiate flowers with prolonged blooming period. Besides, it also recorded greater number of flowers with extended vase life. On the other hand, late planting (16<sup>th</sup> August) gave the flowers with increased diameter and maximum fresh and dry weights per flower.

Dhatt and kumar (2007) in an investigation on effect of planting time on growth, flowering and seed yield of *Coreopsis lanceolata* and *Coreopsis tinctoria* found that among three planting dates (first and last week of November and first week of December), first week of November planting resulted in tallest plants, more number of branches and highest seed yield in *Coreopsis lanceolata* followed by last week of November planting. In case of *Coreopsis tinctoria*, first week of November planting resulted in tallest plants whereas wider spread and maximum seed yield were recorded under last week of November planting.

Kizil *et al.* (2008) working on *Fritillaria imperialis* and *Fritillaria persica* reported that both the species recorded higher values for growth and flowering characters and also for bulb and bulblet production from early and

mid-September plantings compared to early and mid-October plantings. September was concluded to be the most suitable month for planting *Fritillaria*.

In an experiment on *Calendula officinalis*, Seghatolesslami and Mousavi (2009) observed that out of three sowing dates (30<sup>th</sup> March, 14<sup>th</sup> April and 30<sup>th</sup> April) and three plant densities (plant distances on rows were 10, 20 and 30 centimeters), the latest sowing date had the highest flower and seed harvest index. In total, the result showed that the first sowing date with 25 plants/m<sup>2</sup> had the highest grain and flower yield.

A study on *Allium aflatunense* by Laskowska *et al.* (2012) showed that the highest number of flowers per inflorescence and maximum peduncle diameter were resulted from mid-September planting while October planting resulted in production of inflorescences of greater diameter.

Another study on effect of planting time on flowering of four *Lachenalia* cultivars by Kapczynska (2012) showed that out of December, January and February planted bulbs of *Lachenalia*, earliest bloom was observed in bulbs planted in January and February, while bulbs planted in December required longer period to bloom. It was concluded that the date of planting had an effective role in influencing flower yield, length of inflorescence stem, number and diameter of flowers.

## **2.2 Effect of spacing:**

### **2.2.1 Effect of spacing on growth and flowering of golden rod**

Ryagi and Nalawadi (1996) studied the effect of plant density and different nitrogen levels on yield and yield attributing characters of golden rod in which plants were grown at spacing of 45x20, 45x30 and 45x40 cm and supplied with 0, 25, 50, 75 and 100 kg N/ha. The result showed that flower yield increased with closer spacing (from 5.00 to 8.71 t/ha. at 45x40 and 40x20, respectively).

In a similar experiment, Sodha and Dhaduk (2002) studied the effect of spacing and nitrogen on *Solidago canadensis* involving three spacing (30x20, 30x30 and 30x40 cm) and four nitrogen rates (0, 50, 100 and 150 kg/ha). Highest values for growth and flowering attributes such as plant height, number of leaves, number of suckers, plant spread, fresh and dry weight, length of panicle, number of inflorescence branches, spread of inflorescence branches, diameter of panicle, fresh and dry weight of panicle and number of panicles per plant were recorded upon the treatment with the widest spacing and highest nitrogen rate.

Tingare *et al.* (2007) studied the effect of different spacing and nitrogen levels on growth and flower production of *Solidago canadensis*. The result indicated that a spacing of 30x30 cm along with 150 kg N/ha was optimum for the production of desirable quality and yield of flowers.

### **2.2.2 Effect of spacing on growth and flowering of other flowers**

An investigation carried out by Samantaray *et al.* (1999) on African marigold cv. African Yellow revealed that with increase in spacing, the fresh weight of individual flower and flower yield per plant were increased. The maximum yield of flowers per plant was obtained with September planting at spacing of 40x30 cm.

Misra *et al.* (2000) conducted an experiment on tuberose taking different plant spacing viz., 10x30, 15x30, 20x30 and 30x30 cm. It was observed that with closer spacing, the plants took a longer time to produce spikes than wider spaced plants. The spike length and number of florets also decreased in closer-spaced plants.

In an experiment to study the effect of spacing and nitrogen on flowering, flower quality and post-harvest life of gladiolus cv. Red Beauty (Bijimol and Singh, 2001), four spacing and four nitrogen rates were taken. The result indicated that the corms planted at 25x30 cm supplied with 200 kg

N/ha significantly increased the diameter of spike, number of florets per spike, number of spikes per plant with early emergence of spike. Spacing 25x30 had striking effect on per cent opening of florets per spike and number of open florets with drooping of minimum florets.

Natarajan and Vijaykumar (2002) conducted an experiment on the effect of fertilizer and spacing on seed yield and quality in marigold cv. African Giant. As observed by them, the highest number of flowers per plant, number of seeds per flower, seed yield per plant and plot, 100-seed weight, germination percentage, root and shoot lengths, dry matter production and vigour index were obtained at a spacing of 60x40 cm with N:P:K at 125:125:50 kg/ha.

Sharma and Talukdar (2002) investigated the performance of gladiolus cv. Sylvia at various spacing and observed that among different spacing tried, 45x20 cm and 60x25 cm were better over 30x15 cm for number of sprouts per corm, plant height and breadth of leaves; whereas for flower characters, a spacing of 45x20 cm was the best.

In a study on effect of N, P and spacing on tuberose cv. Single (Mishra *et al.*, 2002), two spacing (15x15 cm, 30x20 cm) were taken. It was observed that different spacing had no visible effect on growth and flowering but significantly higher yield of flowers per plot was obtained under closer spacing of 15x15 cm.

Patel *et al.* (2002) studied the influence of spacing and nitrogen levels on spider lily taking nine plant spacings and three levels of nitrogen. Out of nine plant spacings (90x20 cm, 90x30 cm, 90x40 cm, 75x20 cm, 75x30 cm, 75x40 cm, 60x20 cm, 60x30 cm and 60x40 cm), a spacing of 90x20 cm recorded the maximum plant height (105.6 cm) which was followed by 75x20cm and 60x20 cm without showing any significant variation. Wider spacing of 90x 40 cm recorded the maximum number and length of leaves. Maximum number of flower stalks per clump, number of flower buds per plant

and flower yield were recorded with spacing of 75x30 cm and nitrogen level of 250 kg/ha.

Nair and Singh (2004) conducted a study to standardize the spacing in gladiolus in Andaman. Based on the experimental results, the optimum spacing was standardized as 25x 30 cm for cultivation in Bay Islands.

Trials conducted on marigold by Vasudev *et al.* (2006) revealed that he plants spaced at 60x45 cm supplied with 315:84:84 kg of NPK/ha recorded maximum number of flowers per plant while it was the least in the plants spaced at 45x30 cm supplied with 225:60:60 kg of NPK/ha.

Dhatt and Kumar (2007) observed early flower initiation (125.14 days) and maximum flower yield (84.51 g/m<sup>2</sup>) with a spacing of 60x30 cm in *Coreopsis lanceolata* compared to wider spacing of 60x60 cm (125.36 days and 62.71 g/m<sup>2</sup>, respectively).

Ramachandrudu and Thangam (2007) recorded delayed opening of first floret (60 days), increased number of florets per spike (11.93), floret diameter (11.13 cm), spike girth (2.83 cm), corm diameter (4.57 cm) and corm weight (30.40 g) with a spacing of 45x20 cm in gladiolus.

Experimenting with *Gaillardia aristata*, Dhatt and Kumar (2008) reported that the plants spaced at 60x60 cm took 123.31 days to anthesis and showed longest flowering duration (86.87 days). It also resulted in highest seed yield of 106.75 g/m<sup>2</sup>.

Dalvi *et al.* (2008) noticed decreased plant height (120.21 cm), increased number of leaves (10.34), leaf length (59.72 cm) and leaf breadth (2.66 cm) with a spacing of 30x20 cm in gladiolus, whereas wider spacing of 25x30 cm recorded the values of 120.15 cm, 10.22, 59.25 cm and 2.51 cm, respectively for above parameters. Increased number of florets per spike (15.43), yield of spikes per plot (54.66 kg), yield of corms per plot (55.28 kg)

and decreased number of cormels per plant (52.38) were recorded with a spacing of 30x30 cm.

Field experiments were conducted to study the response of spacing (45x45, 45x30, 45x15, 30x30 and 30x15 cm) and crop duration (plant crop, first ratoon and second ratoon) on growth, flower yield and bulb production in tuberose (Malam *et al.*, 2010). The results revealed that wider spacing of 45x45 cm significantly improved plant height, number of leaves, bulbs and bulblets per clump, days to spike emergence, number of spikes per clump, length and diameter of spike, days to flowering, number of florets per spike, diameter of open flower and length of rachis. A planting distance of 30x30 cm realized the highest cut flower yield whereas; a closer spacing of 30x15 cm recorded the highest bulb production.

Rohidas *et al.* (2010) studied the effect of spacing on flowering and vase-life of gladiolus cv. H.B. Pitt, taking four spacing viz., 30x15 cm, 30x20 cm, 30x25 cm and 30x30 cm as treatments. The result revealed that length of spike, length of floret, weight of spike and vase life were highest at 30x30 cm spacing. Girth of floret and number of florets per spike were highest at 30x25 cm spacing. Earliest emergence of 1st spike was found at 30x15 cm spacing. The effect of spacing didn't show any significant effect on days of emergence of first floret.

In an experiment on gladiolus cv. White Prosperity (Bhat *et al.*, 2010), three spacing ( 10x20 cm, 15x20 cm and 20x20 cm) and three corm sizes (4.1-4.5 cm, 4.6-5.0 cm and 5.1-5.5 cm) were taken as treatments. Highest values for plant height, number of corms, cormels and weight of cormels were obtained from wider spacing with larger corm size. On the other hand, numbers of florets per spike and floret diameter were best at a spacing of 20x20 cm along with corm size of 5.1-5.5 cm.

Kazaz *et al.* (2011a) conducted a study to determine the effect of different planting densities and systems on yield and quality of spray carnations taking eight different treatments viz., S<sub>1</sub>: 40 plants/m<sup>2</sup> with 4 rows, S<sub>2</sub>: 45 plants/m<sup>2</sup> with 5 rows, S<sub>3</sub>: 50 plants/m<sup>2</sup> with 5 rows, S<sub>4</sub>: 48 plants/m<sup>2</sup> with 6 rows, S<sub>5</sub>: 54 plants/m<sup>2</sup> with 6 rows, S<sub>6</sub>: 54 plants/m<sup>2</sup> with 6 rows, S<sub>7</sub>: 44 plants/m<sup>2</sup> with a triangular shape and S<sub>8</sub>: 59 plants/m<sup>2</sup> with a triangular shape. The result indicated that the longest stem was recorded in S<sub>8</sub> and shortest in S<sub>1</sub>. Highest yield per plant was observed in S<sub>1</sub> while the lowest was found in S<sub>8</sub>. Days to flowering (50%) in S<sub>1</sub> was found about 7.5 days earlier than S<sub>8</sub>.

In a similar experiment (Kazaz *et al.*, 2011b), eight treatments with different planting densities and systems (viz., S<sub>1</sub>: 40 plants/m<sup>2</sup> with 4 rows, S<sub>2</sub>: 45 plants/m<sup>2</sup> with 5 rows, S<sub>3</sub>: 50 plants/m<sup>2</sup> with 5 rows, S<sub>4</sub>: 48 plants/m<sup>2</sup> with 6 rows, S<sub>5</sub>: 54 plants/m<sup>2</sup> with 6 rows, S<sub>6</sub>: 54 plants/m<sup>2</sup> with 6 rows, S<sub>7</sub>: 44 plants/m<sup>2</sup> with a triangular shape and S<sub>8</sub>: 59 plants/m<sup>2</sup> with a triangular shape) were included assess their effects on yield and quality of standard carnation. The results showed that the highest yields per plot were found in S<sub>1</sub> and S<sub>2</sub>, whereas the lowest yields were obtained from S<sub>8</sub> and S<sub>6</sub>. It was concluded that stem length and total yield per m<sup>2</sup> increased with increasing plant densities, whereas stem diameter, dry matter content, vase-life and yield per plant decreased.

Berimavandi *et al.* (2011) studied the effect of plant densities and sowing date on growth, flowering and quantity of essential oil of *Calendula officinalis*, taking 4 levels of plant densities (20, 40, 60 and 80 plants per m<sup>2</sup>) and 3 sowing dates (April 19, April 29 and May 10). The result of the study revealed that maximum plant dry weight, flower number per plant, branches per plant, flower dry weight and amount of essential oil/100 g dried flower were obtained at 20 plants/m<sup>2</sup>, while maximum flower dry weight and amount of essential oil, both per unit area were obtained at 60 plants/m<sup>2</sup>.

In an experiment on effect of planting distance and cultivation depth on some quantitative traits of narcissus cut flower (Dhaneshvar and Heidari, 2011), it was found that the highest number of cut flowers were obtained at 15 cm distance with 10 cm depth, the longest stem at 15 cm distance with 15 cm depth and the highest floret diameter at 20 cm distance with 10 cm depth. The result showed that interaction of planting distance and depth had significant effect on flowering time but didn't significantly affect the number of florets, floret diameter and open floret at the time of harvesting.

Khobragade *et al.* (2012) in an investigation on China aster cv. Poornima observed that out of six spacings tried (20x10, 30x10, 40x10, 30x20, 30x30 and 40x20 cm), the close spacing of 20x10 cm produced taller plants with higher flower yield per unit area than wider spacing.

Effect of plant spacing on tuberose was studied by Khalaj *et al.* (2012). They took several plant spacings viz., 10, 15, 20 and 25 cm. Results showed that the 25 cm plant space had a significant effect on flower stalk height, stem diameter, spike length, floret diameter, floret weight, vase life and nutrient uptake which were improved as compared to other spacings tried.

Dorajeerao *et al.* (2012) studied the effect of plant spacing on yield and quality of garland chrysanthemum. It was found that flower yield /ha was the highest at 30x30 cm spacing which was at par with 30x40 cm spacing. The number of flowers per plant increased with increased spacing the highest being recorded at 60x60 cm. Mean flower diameter, hundred flower weight and thousand seed weight increased with increasing levels of spacing from 30x30 cm to 60x60 cm.

Sharma *et al.* (2012) studied the effect of spacing and pinching on flowering of African marigold under submontane low hill conditions of Himachal Pradesh. The highest flower yield of 203 q/ha was obtained with a combination of plant spacing at 45x60 cm and pinching of terminal shoots on

30<sup>th</sup> day after transplanting. This combination was found superior to flower yields obtained under solo application i.e. either spacing or pinching was accompanied by better plant growth, larger and higher number of flowers per plant and therefore, considered optimum for high flower yield.

An experiment was conducted to assess the effect of spacing and salicylic acid levels on vegetative growth and flowering of gladiolus cv. White Prosperity (Maniram *et al.*, 2012). Three levels of spacing (20x10, 20x20 and 20x30 cm) and three levels of salicylic acid (0, 50 and 100 ppm) were used out of which an optimum spacing of 20x20 cm was found superior with 100 ppm salicylic acid in respect of number of leaves, leaf length, days to opening of first floret, visibility of first spike, spike length and number of florets per spike.

A study was conducted to standardize production and post-harvest handling of *Lilium longifolium* cv. Mero Star (Amjad and Ahmad, 2012) in which three plant densities viz., 10, 20 and 30 cm between plants in 60 cm spaced rows and two planting depths viz., 7.5 and 15 cm were compared. Increased plant growth, yield and quality were recorded at closer spacing of 10 cm with 15 cm planting depth. For liliun production, higher plant density with deeper bulb planting proved better.

CHAPTER - III

Materials & Methods



## MATERIALS AND METHODS

The present investigation was carried out in form of a field experiment in the garden of the Department of Floriculture & Landscaping, College of Agriculture, Orissa University of Agriculture and technology, Bhubaneswar, during 2011-12. The details of materials used and methods adopted during the course of experiment are presented in this chapter.

### **3.1 GEOGRAPHICAL LOCATION OF THE EXPERIMENTAL SITE:**

The Department of Floriculture & Landscaping, OUAT, Bhubaneswar is situated 63 km away from the Bay of Bengal, at an elevation of 25.5 m above MSL. Geographically it is located at 20<sup>0</sup>15' North latitude and 85<sup>0</sup>15' East longitude.

### **3.2 CLIMATE:**

Bhubaneswar comes under subtropical climate. The mean annual precipitation is 1522 mm, out of which about 85% is received within July to September and the rest is within October to June. While the average maximum temperature ranges from 35<sup>0</sup>c to 40<sup>0</sup>c during May to June, the minimum temperature varies from 13<sup>0</sup>c to 15<sup>0</sup>c during December to January. The RH varies between 40% in summer to 90% in rainy season. The weather condition prevailing during the period of investigation i.e. from August, 2011 to June, 2012 has been shown in Appendix-I as per the meteorological data recorded in the university observatory situated close to the experimental site.

### **3.3 CROPPING HISTORY OF THE EXPERIMENTAL FIELD:**

The cropping history of the experimental field for the previous 3 years of experimentation is as follows:

**Table 1: Cropping history of the experimental plot:**

Year	Summer	Kharif	Rabi
2007-08	Fallow	Fallow	Fallow
2008-09	Fallow	Fallow	Fallow
2009-10	Fallow	Fallow	Fallow

### 3.4 SOIL CHARACTERISTICS:

Prior to conducting the experiment, soil samples were collected from a depth of 15 cm from several spots of the experimental area. Composite sample was then prepared and 1 Kg of the composite sample was collected in polythene bag for analysis to determine the mechanical and chemical composition. The results of the analysis are presented in table 2 and 3.

### 3.5 VARIETAL DESCRIPTION:

Golden rod (*Solidago canadensis* L.) cv. Local yellow was selected for this experiment. The pretty golden yellow flowers are feather like and crowded in a long terminal panicle. This plant is characterized by hairy upper stem. It can grow up to a height ranging between 60 cm to 1.5 m. The leaves are linear to lanceolate having serrated margins. Stems are having smooth texture.

### 3.6 COLLECTION OF PLANTING MATERIALS:

The suckers of goldenrod used as planting materials were collected from a field of Department of Floriculture & Landscaping, inside the University campus. The planting materials were about a month old and 15-18 cm in height.

### 3.7 EXPERIMENTAL DETAILS:

The experiment was conducted in order to study the effect of different planting dates and spacing on growth and flower yield of golden rod.

**Table 2: Mechanical composition of the soil (0-15 cm)**

Mechanical constituents	Percentage on air dry basis	Method employed
Sand	83%	Bouyoucos Hydrometer
Silt	9%	
Clay	8%	

**Textural class:** - Loamy sand

**Table 3: Chemical composition of the soil (0-15 cm)**

Sl. No.	Chemical constituents	Composition	Methods employed
1.	Available nitrogen	235 kg/ha	Modified Kjeldahl method
2.	Available P <sub>2</sub> O <sub>5</sub>	14 kg/ha	Olsen method
3.	Available K <sub>2</sub> O	101 kg/ha	Ammonium acetate
4.	Organic carbon	2.8 g/kg of soil	Walkley and black low rapid titration method
5.	pH	6.35	Glass electrode Blackman's
6.	Electrical conductivity	0.096 (dS/m)	Conductivity bridge

### 3.7.1 STATISTICAL DESIGN:

The experiment was laid out in a Factorial Randomized Block Design having 3 replications. The treatments were allotted randomly and equally to each replication.

### 3.7.2 TREATMENTS:

The experiment consisted of two factors viz., planting date and spacing.

#### (i) Main plot treatments

There were three main plots corresponding to three planting dates.

Planting dates	Code (D)
20 <sup>th</sup> August, 2011	D <sub>1</sub>
20 <sup>th</sup> September, 2011	D <sub>2</sub>
20 <sup>th</sup> October, 2011	D <sub>3</sub>

#### (ii) Subplot treatments

There were four subplots under each main plot corresponding to four spacings.

Spacing	Code (S)
40 cm x 30 cm	S <sub>1</sub>
40 cm x 40 cm	S <sub>2</sub>
60 cm x 30 cm	S <sub>3</sub>
60 cm x 40 cm	S <sub>4</sub>

3.7.3 Number of replications: 3

3.7.4 Plot size: (subplot) –

Net- 2.4 m x 2.4 m

Gross- 2.7 m x 2.7 m

3.7.5 Width of bond: 0.3 m

3.7.6 Number of plants per plot:

S1 – 48                      S2 – 36

S3 – 32                      S4 – 24

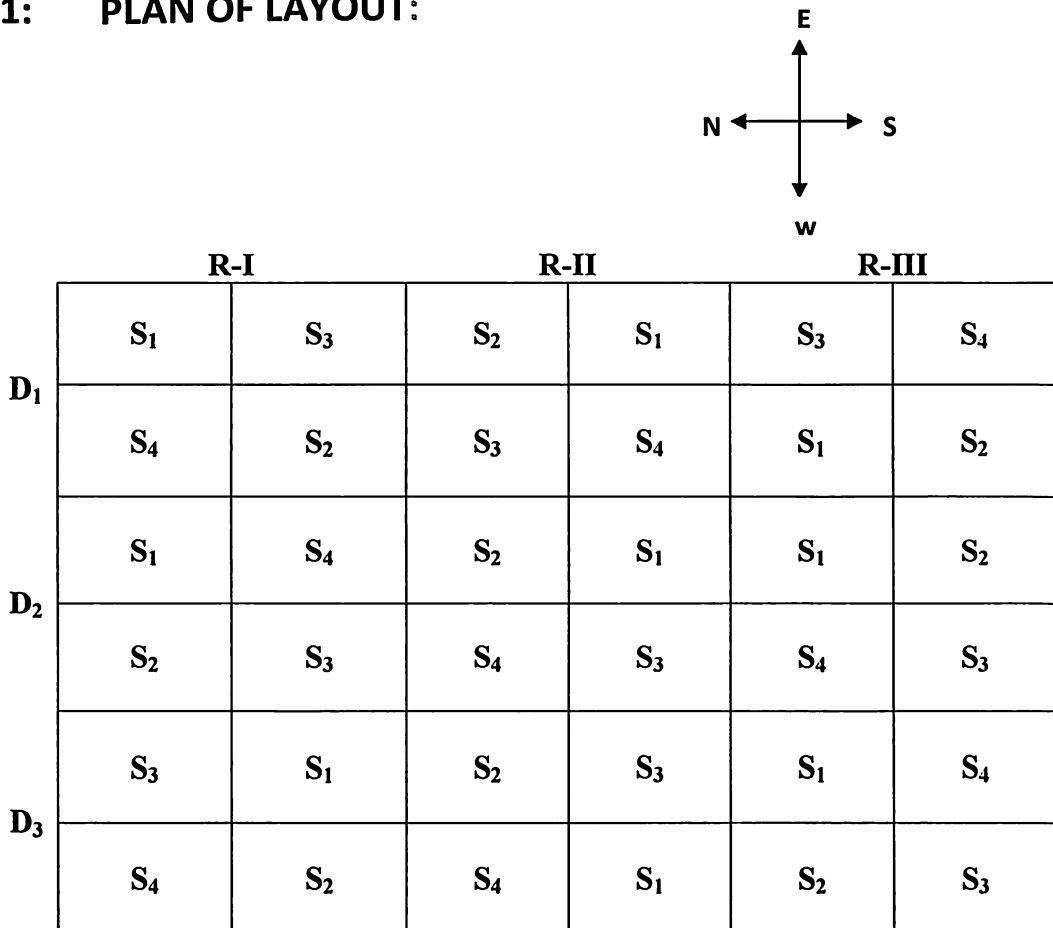
3.7.7 Total number of plots: 36

3.7.8 Area of experimental site

a) Gross cropped area = 262.44 m<sup>2</sup>

b) Net cropped area = 207.36 m<sup>2</sup>

Fig. 1: PLAN OF LAYOUT:



Main plot treatments (Planting Date 'D')      Sub-plot treatments (Spacing 'S')

D<sub>1</sub>- 20<sup>th</sup> August, 2011

S<sub>1</sub>- 40x30 cm

D<sub>2</sub>- 20<sup>th</sup> September, 2011

S<sub>2</sub>- 40x40 cm

D<sub>3</sub>- 20<sup>th</sup> October, 2011

S<sub>3</sub>- 60x30 cm

S<sub>4</sub>- 60x40 cm



**Plate 1. Field view of experimental field**

### **3.8 EXECUTION OF THE EXPERIMENT:**

#### **3.8.1 Preparation of the experimental site:**

The experimental site was lying fallow for long, severely infested with weeds. So it was dug and cleaned prior to commencement of the experiment. Then the land was tilled, leveled properly and plots were laid out as per the plan. The main and subplot treatments were allotted randomly according to the random table.

#### **3.8.2 Preparation of planting materials:**

The healthy suckers of golden rod having a length of 15-18 cm and about a month old were selected and uprooted just before planting. Immediately after uprooting, the roots were kept immersed in a bucket of clean water and kept under shade. The dry leaves were cut and removed. Besides, the excessively grown roots were also trimmed prior to transplanting.

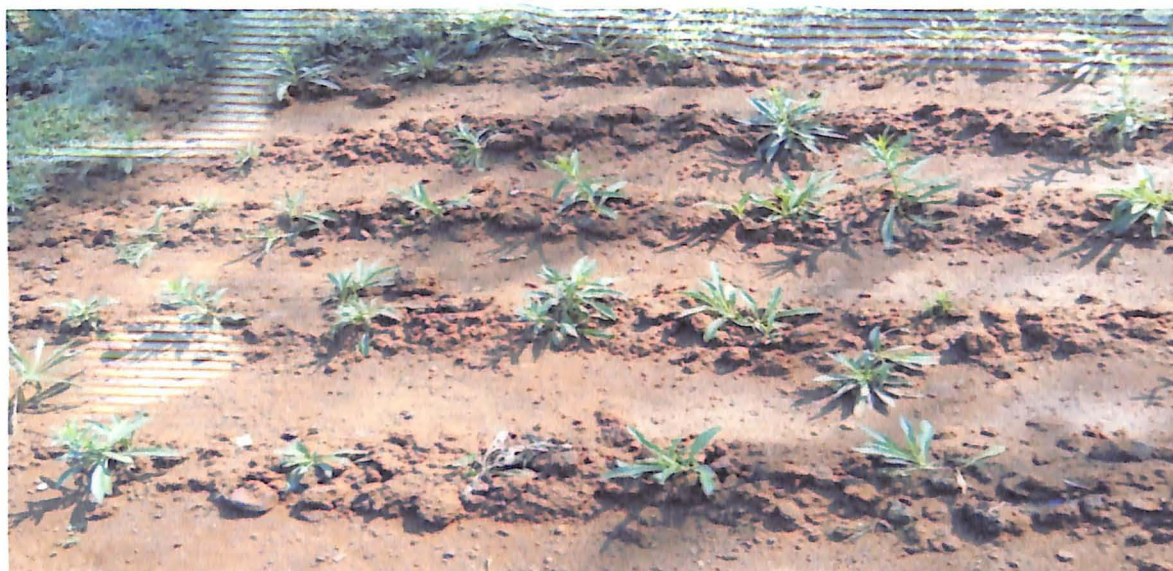
#### **3.8.3 Preparation of subplots:**

The subplots under each main plot, scheduled to be planted on each planting date as per the plan, were brought to a fine tilth by repeated digging, hoeing and breaking clods. Then weeding was done and plots were leveled properly. Preparation of plots was completed about 15 days ahead of each planting date.

#### **3.8.4 Application of manures and fertilizers:**

Well decomposed FYM @ 10 t/ha was applied at the time of final land preparation and incorporated thoroughly into the soil. The chemical fertilizers were applied in three split doses in the following manner;

Recommended fertilizer dose for the crop is 150-100-100 kg/ha of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively. One third nitrogen with full phosphorus and half



**Plate 2. Different stages of plant growth & flowering in golden rod**

potash was applied as basal at the time of transplanting. Again one third nitrogen along with rest half of the potash was applied a month after first fertilizer application to the crop as first topdressing. The second topdressing was done with rest one third of nitrogen a month after the first topdressing. The nutrients N<sub>2</sub>, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied in the form of urea, single super phosphate and muriate of potash as per requirement.

### **3.8.5 Transplanting:**

Healthy suckers having an average height of 15-18 cm and uniform growth were used for transplanting in the plots. Transplanting was done three times corresponding to three planting dates, all during the evening hours. In any case if the field was found dry, the plots were irrigated in the morning prior to transplanting. The plots were again irrigated by using a hose pipe after completion of transplanting.

### **3.8.6 Aftercare of the experimental plot:**

#### **3.8.6.1 Gap filling**

Gap filling was done with fresh seedlings a week after transplanting wherever necessary, in order to maintain 100 % plant population in each plot.

#### **3.8.6.2 Irrigation**

A pre-planting irrigation was provided to the experimental plots if the soil was found to be dry. Also after transplanting, the plots were irrigated lightly using a hose pipe. Besides, the plots were irrigated at alternate days for a week after transplanting using a hose pipe so as to let the suckers get established. Thereafter irrigation was provided at 5-7 days interval depending on the soil moisture status.

### **3.8.6.3 Plant protection**

No incidence of disease or insect pest was noticed during the experimental period.

### **3.8.6.4 Weeding**

The experimental plots were kept clean and weed free by regular hand weeding.

### **3.8.6.5 Earthing up and staking**

In order to support the plants, earthing up was done manually. Stakes were provided to maintain the upright growth of the plants at the time of appearance of inflorescence.

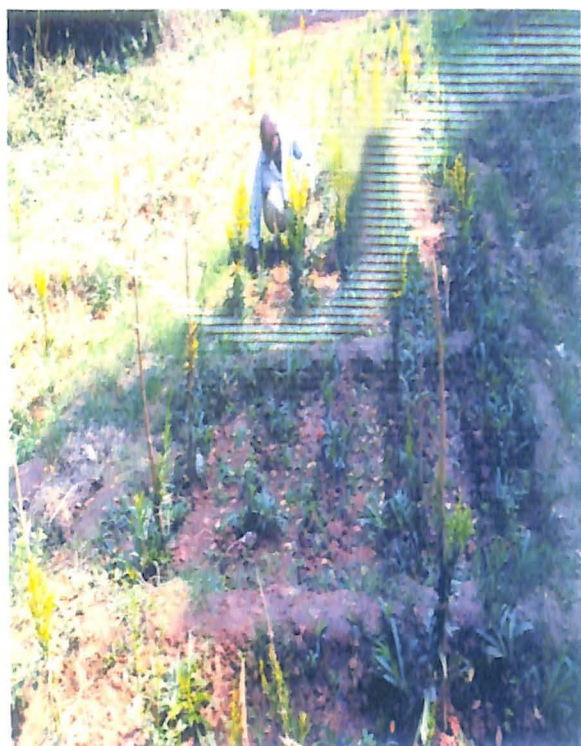
### **3.8.6.6 Harvesting**

When the panicles reached full bloom stage, these were harvested by cutting the flower stalk from the base along with few leaves attached, the first harvest commencing from three and half months after transplanting which continued for about two months. During harvesting the flower stalks were cut by a sharp knife. The cut stalks were immediately put in plastic bucket containing clean water so that the cut base of the stalks remained immersed in water. Harvesting was done during the morning hours.

## **3.8.7 Collection of experimental data:**

### **3.8.7.1 Sampling procedure**

Five plants at random from each plot were tagged for the purpose of recording experimental data, leaving the plants from borders. The mean of the recorded five readings from sample plants for each growth and flowering parameters was calculated and used for analysis.



**(a)**



**(b)**



**(b)**



**(d)**

**Plate 3. Field operations [(a) Weeding, (b) watering, (c) Staking, (d) Harvesting]**

### **3.8.7.2 Observations on growth parameters**

Observations on different growth parameters were recorded thrice, the first one commencing after 45 days of transplanting and subsequently at two months interval.

The growth characters recorded were as follows:

#### **1) Plant height**

The height of the plant was measured from the ground level to the highest point of growth and expressed in centimeter.

#### **2) Number of leaves per clump**

Total number of leaves of each sample plant as well as from the suckers of that particular plant were counted and recorded.

#### **3) Stem girth**

The stem thickness was measured by a slide caliper at the base of the main stem of each sample plant and was expressed in centimeter.

#### **4) Number of suckers per plant**

Total number of suckers emerging around the main sample plant were counted and recorded.

### **3.8.7.3 Observations on flowering components and flower characters**

#### **1) Days taken for initiation of flower panicle**

The number of days taken for appearance of the flower panicle in each sample plant was found out by counting the days from the date of transplanting to the date of appearance of panicle.

**2) Number of panicles per clump**

Total number of panicles in the clump i.e. in the main plant as well as the plants arising from the base of the main plant, were counted and recorded.

**3) Length of the flower panicle**

The length of the flower panicle was measured from the point of emergence of plant up to the tip and expressed in centimeters.

**4) Number of primary branches per panicle**

The number of branches arising from the panicle of the main stem of each sample plant were counted and recorded.

**5) Spread of primary branches of panicle**

The maximum horizontal spread of the individual panicle was measured.

**6) Days taken for first flowering**

The date of appearance of first fully open flower in the panicle on individual sample plant was recorded and the number of days taken for first flowering was found out by counting the days from the date of transplanting to the date of appearance of fully open flower in the panicle.

**7) Rachis length**

Rachis length of the flower panicle was found out by measuring the length of flowering zone in the panicle i.e. from the point of initiation of lowermost primary branch up to the tip of the panicle and expressed in centimeter.

**8) Longevity of flower panicle in the field**

It was determined by counting the days from the date of attainment of full bloom stage of the flower panicle up to the date of initiation of browning of the flowers.

**9) Yield of flower panicles per hectare**

Yield of panicle per hectare was computed by using the yield figures of individual plot under various treatments.

**10) Economics**

The cost of cultivation with respect to the treatments showing better performance was worked out taking the inputs and labour cost into consideration.

**3.9 STATISTICAL ANALYSIS:**

All the data concerning various observations on growth parameters and flowering components were analyzed statistically. The analysis of variance table was prepared and the treatment effects were tested by F-test at 5% level of significance. The CD at 5% level was calculated to compare the treatment means.

CHAPTER - IV

# Experimental Results



## EXPERIMENTAL RESULTS

The results obtained from the experiment entitled “Effect of planting date and spacing on growth and flower yield of golden rod (*Solidago canadensis* L.)” conducted during 2011-12 at floriculture unit of College of Agriculture, OUAT, Bhubaneswar are presented in this chapter.

### 4.1 EFFECT OF PLANTING DATE AND SPACING ON GROWTH PARAMETERS

#### 4.1.1 Plant height

Observations on plant height as influenced by different planting dates and spacings as well as their combinations were recorded at 45, 105 and 165 days after transplanting (DAT) and the data so obtained are presented in Table 4 Fig.2.

The data revealed that the plant height differed significantly at all stages of plant growth due to different planting dates and spacings provided.

At 45 DAT, plant height was significantly higher in September planting (23.69 cm) followed by August planting (20.68 cm) and it was the lowest in October planting (19.07 cm). At 105 DAT, significantly higher plant height (46.41 cm) was recorded with September planting followed by August planting (43.84 cm) and the lowest was observed (38.82 cm) with October planting. At 165 DAT, highest value for plant height was also recorded with September planting (138.44 cm) followed by October planting (121.92 cm) while the least was with August planting (116.15 cm).

Significant difference in plant height was also found due to different levels of spacings. At 45 DAT significantly higher plant height (23.20 cm) was recorded with S<sub>1</sub> (40x30 cm) which was followed by S<sub>2</sub> viz., 40x40 cm (21.69 cm) and the least (19.09 cm) being recorded with S<sub>4</sub> (60x40 cm). At 105 DAT, the same trend was noticed with the highest plant height being recorded with S<sub>1</sub>

(45.99 cm) followed by  $S_2$  (43.86 cm) and the least with  $S_4$  (40.16 cm). At 165 DAT when highest value for plant height was also recorded with  $S_1$  (126.90 cm) followed by  $S_2$  (125.62 cm) and  $S_3$  (125.16 cm), the lowest was recorded with  $S_4$  (124.34 cm).

Plant height was also significantly influenced by various combinations of planting dates and spacings. At 45 DAT, plants under September planting with 40x30 cm spacing ( $D_2S_1$ ) resulted in maximum height (25.72 cm) and it was closely followed by  $D_2S_2$  (24.63 cm) without showing any significant variation from each other. On the other hand those planted in October with 60x40 cm spacing ( $D_3S_4$ ) recorded the minimum (16.80 cm). At 105 DAT, plants under September planting with 40x30 cm spacing ( $D_2S_1$ ) also recorded the maximum plant height (48.82 cm) which was followed by the same recorded under  $D_2S_2$  (47.50 cm). The minimum (34.96 cm) was recorded with those planted in October with a spacing of 60x40 cm ( $D_3S_4$ ). At 165 DAT, highest plant height (141.65 cm) was obtained with those planted in September with a spacing of 60x30 cm ( $D_2S_3$ ) followed by  $D_2S_4$  (141.19 cm) without showing significant variation from each other. On the other hand the lowest (111.62 cm) was observed with those planted in August with a spacing of 60x40 cm ( $D_1S_4$ ).

#### **4.1.2. Number of leaves per clump**

Observations on number of leaves per clump as influenced by different planting dates, spacings and their interaction 45, 105 and 165 DAT were recorded and the data so obtained were statistically analyzed and presented in the Table 5 Fig.3

**Table 4: Effect of planting date, spacing and their interaction on Plant height in golden rod**

Treatment	Plant Height (cm)		
	45 DAT	105 DAT	165 DAT
<b>Planting Date (D)</b>			
D <sub>1</sub>	20.68	43.84	116.15
D <sub>2</sub>	23.69	46.41	138.44
D <sub>3</sub>	19.07	38.82	121.92
SE(m) <sub>±</sub>	0.19	0.15	0.11
CD at 5%	0.55	0.45	0.32
<b>Spacing (S)</b>			
S <sub>1</sub>	23.20	45.99	126.90
S <sub>2</sub>	21.69	43.86	125.62
S <sub>3</sub>	20.61	42.08	125.16
S <sub>4</sub>	19.09	40.16	124.34
SE(m) <sub>±</sub>	0.22	0.18	0.12
CD at 5%	0.64	0.52	0.37
<b>Interaction (DxS)</b>			
D1S1	22.08	45.66	121.00
D1S2	20.75	45.02	119.54
D1S3	20.23	42.92	112.46
D1S4	19.68	41.79	111.62
D2S1	25.72	48.82	136.13
D2S2	24.63	47.50	134.81
D2S3	23.62	45.58	141.65
D2S4	20.80	43.73	141.19
D3S1	21.81	43.50	123.58
D3S2	19.70	39.08	122.51
D3S3	17.98	37.74	121.38
D3S4	16.80	34.96	120.21
SE(m) <sub>±</sub>	0.38	0.31	0.22
CD at 5%	1.11	0.90	0.64

D<sub>1</sub>- 20<sup>th</sup> August planting

D<sub>2</sub>- 20<sup>th</sup> September planting

D<sub>3</sub>- 20<sup>th</sup> October planting

S<sub>1</sub>- 40x30 cm

S<sub>2</sub>- 40x40 cm

S<sub>3</sub>- 60x30 cm

S<sub>4</sub>- 60x40 cm

As indicated in Table 5, number of leaves per clump was significantly influenced by different planting dates. At 45 DAT, significantly higher number of leaves (70.33) was recorded in August planted crop followed by the same produced during September planting (38.05) whereas the least (30.61) was recorded in October planted crop. At 105 DAT, the highest number of leaves (139.06) was also observed in August planting followed by September planting (119.35) and the least (94.61) was in October planting. At 165 DAT, those planted in September recorded the highest value for number of leaves (218.68) closely followed by those planted in August (216.18) whereas those planted in October recorded the lowest value (208.35).

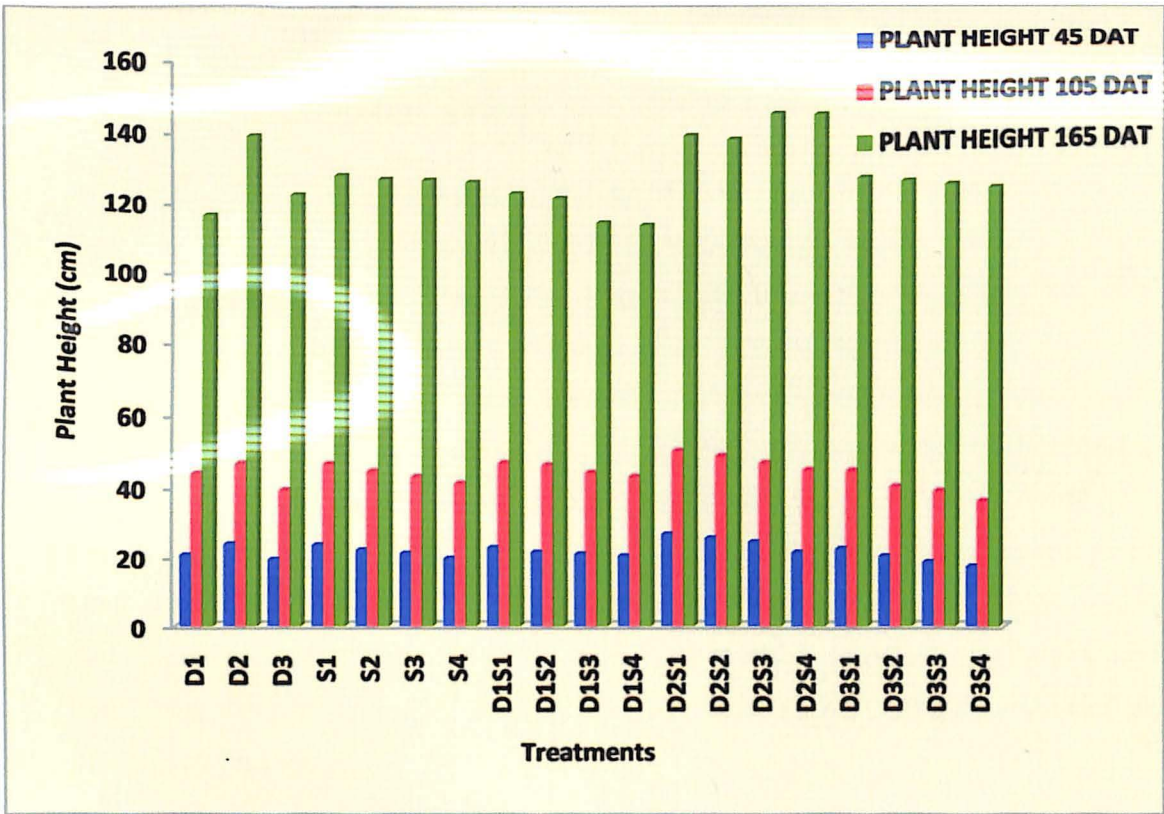
Significant variation in number of leaves per clump was found due to different levels of spacings. At 45 DAT, highest number of leaves (55.57) was recorded with 60x40 cm spacing and it was followed by those recorded with 60x30 cm spacing (48.60). On the other hand the lowest (37.53) was recorded with 40x30 cm spacing. At 105 DAT, highest number of leaves (124.31) was observed with a spacing of 60x40 cm. It was followed by 60x30 cm spacing which recorded 122.13 leaves, the lowest (106.77) being recorded with 40x30 cm. At 165 DAT, the same trend was observed and the highest value (218.57) was recorded with 60x40 cm spacing followed by 60x30 cm (216.42) and the lowest (208.86) was with 40x30 cm spacing.

Number of leaves per clump was significantly influenced by various combinations of planting dates and spacings. At 45 DAT, plants under August planting with a spacing of 60x40 cm ( $D_1S_4$ ) resulted in maximum number of leaves per plant (85.73) followed by  $D_1S_3$  (73.46) whereas those planted in October with a spacing of 40x30 cm ( $D_3S_1$ ) recorded the minimum number of leaves per plant (27.46). However, it was at par with those recorded under  $D_2S_1$ ,  $D_3S_2$ ,  $D_3S_3$  and  $D_3S_4$  combinations. At 105 DAT, plants under August planting with 60x40 cm spacing ( $D_1S_4$ ) gave highest number of leaves (149.93) closely followed by  $D_1S_3$  (147.20) and the lowest (89.06 leaves) being recorded in plants under October planting with 40x30 cm spacing ( $D_3S_1$ ). At 165 DAT, highest number of leaves (222.80) was recorded under September planting with 60x40 cm spacing ( $D_2S_4$ ) followed by  $D_2S_3$  (220.80) and the lowest (198.86) under October planting with 40x30 cm spacing ( $D_3S_1$ ).

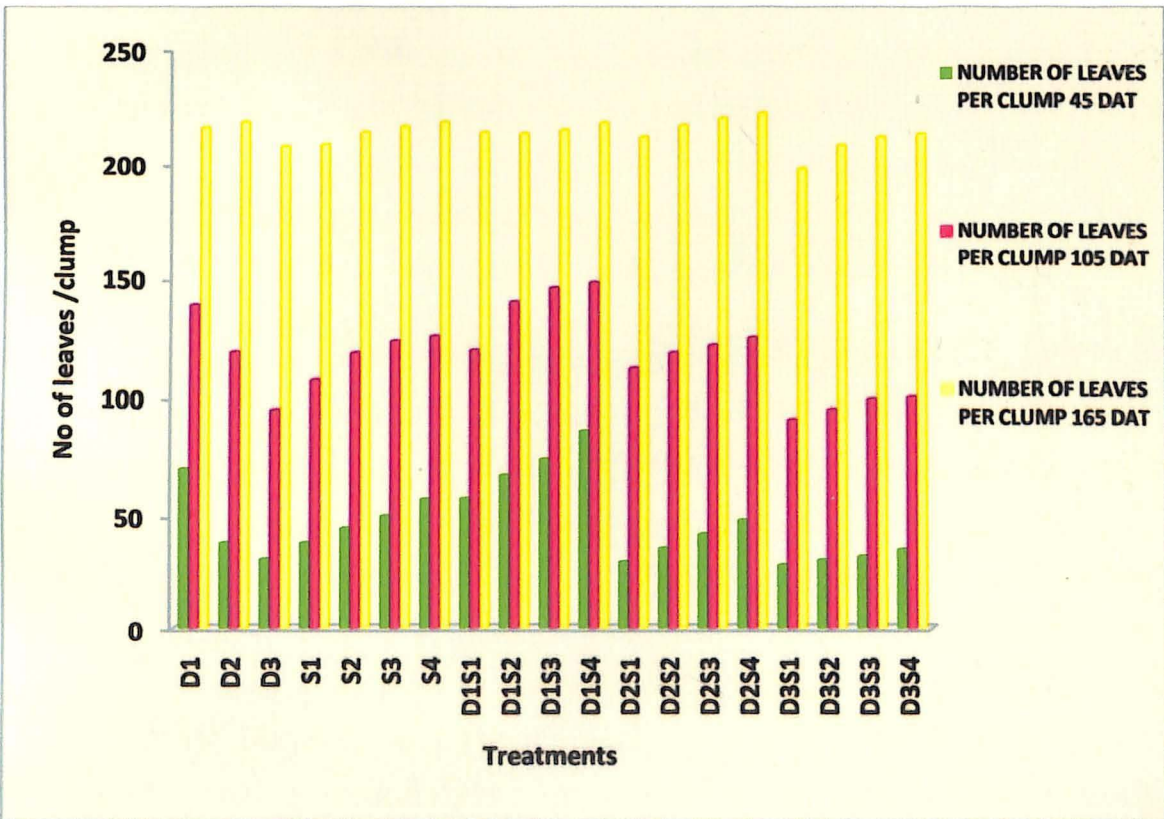
**Table 5: Effect of planting date, spacing and their interaction on Number of leaves per clump in golden rod**

Treatment	Number of leaves per clump		
	45 DAT	105 DAT	165 DAT
<b>Planting Date (D)</b>			
D <sub>1</sub>	70.33	139.06	216.18
D <sub>2</sub>	38.05	119.35	218.68
D <sub>3</sub>	30.61	94.61	208.35
SE(m) <sub>±</sub>	1.24	0.29	0.21
CD at 5%	3.60	0.83	0.62
<b>Spacing (S)</b>			
S <sub>1</sub>	37.53	106.77	208.86
S <sub>2</sub>	43.62	117.48	213.75
S <sub>3</sub>	48.60	122.13	216.42
S <sub>4</sub>	55.57	124.31	218.57
SE(m) <sub>±</sub>	1.43	0.33	0.25
CD at 5%	4.15	0.96	0.72
<b>Interaction (DxS)</b>			
D <sub>1</sub> S <sub>1</sub>	55.93	118.66	214.53
D <sub>1</sub> S <sub>2</sub>	66.20	140.46	214.60
D <sub>1</sub> S <sub>3</sub>	73.46	147.20	216.40
D <sub>1</sub> S <sub>4</sub>	85.73	149.93	219.40
D <sub>2</sub> S <sub>1</sub>	29.20	112.60	213.20
D <sub>2</sub> S <sub>2</sub>	35.06	118.80	217.93
D <sub>2</sub> S <sub>3</sub>	41.06	121.53	220.80
D <sub>2</sub> S <sub>4</sub>	46.86	124.46	222.80
D <sub>3</sub> S <sub>1</sub>	27.46	89.06	198.86
D <sub>3</sub> S <sub>2</sub>	29.60	93.20	208.73
D <sub>3</sub> S <sub>3</sub>	31.26	97.66	212.26
D <sub>3</sub> S <sub>4</sub>	34.13	98.53	213.53
SE(m) <sub>±</sub>	2.49	0.58	0.43
CD at 5%	7.20	1.67	1.25

D<sub>1</sub>- 20<sup>th</sup> August plantingD<sub>2</sub>- 20<sup>th</sup> September plantingD<sub>3</sub>- 20<sup>th</sup> October plantingS<sub>1</sub>- 40x30 cmS<sub>2</sub>- 40x40 cmS<sub>3</sub>- 60x30 cmS<sub>4</sub>- 60x40 cm



**Fig.2 Effect of planting date, spacing and their interaction on plant height in goldenrod**



**Fig.3 Effect of planting date, spacing and their interaction on number of leaves per clump**

### 4.1.3 Stem girth

The analyzed data on stem girth are presented in Table 6 and Fig. 4.

The data revealed that stem girth was significantly influenced by different planting dates. At 45 DAT, it was highest (7.84 cm) with those planted in September followed by August planting (7.65 cm) and was least (7.37 cm) with those planted in October. However, no significant variation was noticed in stem girth in plants under August and October planting. At 105 DAT, highest value for stem girth (9.22 cm) was recorded with October planting followed by September planting (9.08 cm) without showing any significant variation from each other. On the other hand it was observed to be least (8.21 cm) in August planted crop. At 165 DAT, stem girth was highest (10.25 cm) in October planting followed by September planting (10.24 cm) and these two were at par with each other. The least (9.34 cm) was recorded in those planted in August.

Effect of various spacings on stem girth of goldenrod plants was not found to be significant at any stage of plant growth. However, at 45 DAT, it was the highest (7.81 cm) with 60x40 cm spacing and the lowest (7.40 cm) with a spacing of 40x30 cm. At 105 DAT, the same trend was observed with highest value (9.06 cm) recorded with a spacing of 60x40 cm and the lowest (8.67 cm) with a spacing of 40x30 cm. At 165 DAT, the highest value for stem girth (10.07 cm) was recorded with the spacing of 60x30 cm whereas the lowest (9.77 cm) was observed with a spacing of 40x30 cm.

Interaction of different planting dates with spacings had no significant influence over stem girth. However, at 45 DAT, plants under September planting with a spacing of 60x40 cm ( $D_2S_4$ ) resulted in maximum stem girth (7.98 cm), whereas, those planted in October with a spacing of 40x30 cm ( $D_3S_1$ ) recorded the minimum (7.20 cm). At 105 DAT, the highest stem girth (9.43 cm) was observed in September planting with a spacing of 60x40 cm ( $D_2S_4$ ) and the lowest (7.92 cm) in August planting with a spacing of 40x30 cm ( $D_1S_1$ ). At 165 DAT, the highest value for stem girth (10.46 cm) was also recorded with September planting with 60x40 cm spacing ( $D_2S_4$ ) and the lowest (9.16 cm) in August planting with a spacing of 40x30 cm ( $D_1S_1$ ).

**Table 6: Effect of planting date, spacing and their interaction on Stem girth of golden rod**

Treatment	Stem girth (cm)		
	45 DAT	105 DAT	165 DAT
<b>Planting Date (D)</b>			
D <sub>1</sub>	7.65	8.21	9.34
D <sub>2</sub>	7.84	9.08	10.24
D <sub>3</sub>	7.37	9.22	10.25
SE(m)	0.09	0.06	0.06
CD at 5%	0.28	0.18	0.18
<b>Spacing (S)</b>			
S <sub>1</sub>	7.40	8.67	9.77
S <sub>2</sub>	7.56	8.75	9.93
S <sub>3</sub>	7.71	8.87	10.07
S <sub>4</sub>	7.81	9.06	10.00
SE(m)	0.11	0.07	0.07
CD at 5%	NS	NS	NS
<b>Interaction (DxS)</b>			
D <sub>1</sub> S <sub>1</sub>	7.32	7.92	9.16
D <sub>1</sub> S <sub>2</sub>	7.57	8.11	9.47
D <sub>1</sub> S <sub>3</sub>	7.79	8.32	9.54
D <sub>1</sub> S <sub>4</sub>	7.92	8.48	9.18
D <sub>2</sub> S <sub>1</sub>	7.66	8.88	10.00
D <sub>2</sub> S <sub>2</sub>	7.80	8.94	10.08
D <sub>2</sub> S <sub>3</sub>	7.91	9.06	10.40
D <sub>2</sub> S <sub>4</sub>	7.98	9.43	10.46
D <sub>3</sub> S <sub>1</sub>	7.20	9.20	10.15
D <sub>3</sub> S <sub>2</sub>	7.33	9.21	10.24
D <sub>3</sub> S <sub>3</sub>	7.44	9.22	10.26
D <sub>3</sub> S <sub>4</sub>	7.52	9.27	10.37
SE(m)	0.19	0.13	0.12
CD at 5%	NS	NS	NS

D<sub>1</sub>- 20<sup>th</sup> August plantingS<sub>1</sub>- 40x30 cmD<sub>2</sub>- 20<sup>th</sup> September plantingS<sub>2</sub>- 40x40 cmD<sub>3</sub>- 20<sup>th</sup> October plantingS<sub>3</sub>- 60x30 cmS<sub>4</sub>- 60x40 cm

NS- Non significant

#### 4.1.4 Number of suckers per plant

The data recorded on number of suckers per plant as influenced by various planting dates, spacing and their combination at various stages of plant growth are presented in Table 7 and Fig. 5.

The data indicated that the number of suckers per plant was influenced significantly by different planting dates. At 45 DAT, number of suckers were highest (1.51) in August planting followed by September planting (1.23) and both were at par with each other. On the other hand the least (0.80) was recorded in October planting. At 105 DAT, the highest number of suckers (2.41) were also observed in August planting followed by September planting (2.30) without showing any significant variation while the least (1.31) was recorded in October planting. At 165 DAT, number of suckers were highest (3.63) in September planting which differed significantly from other planting dates. It was followed by August planting (2.85). On the other hand, plants under October planting produced the minimum (1.96) number of suckers among all the planting dates under study.

Significant influence of spacing on sucker production was noticed only at 45 and 105 DAT. At 45 DAT, it was observed that plants grown at a spacing of 60x40 cm (S<sub>4</sub>) produced maximum number of suckers (1.51). It was followed by the same recorded with 60x30 cm (1.33) and 40x40 cm (1.11) spacings. However, no significant variation in number of suckers produced per plant was noticed due to these three spacing treatments. On the other hand, the lowest number of suckers (0.77) was produced in plants grown at a spacing of 40x30 cm. However, it was at par with the same recorded with 40x40 cm spacing (1.11 nos.). At 105 DAT, number of suckers were highest (2.51) at 60x40 cm spacing followed by 60x30 cm spacing (2.26) without showing any significant variation.

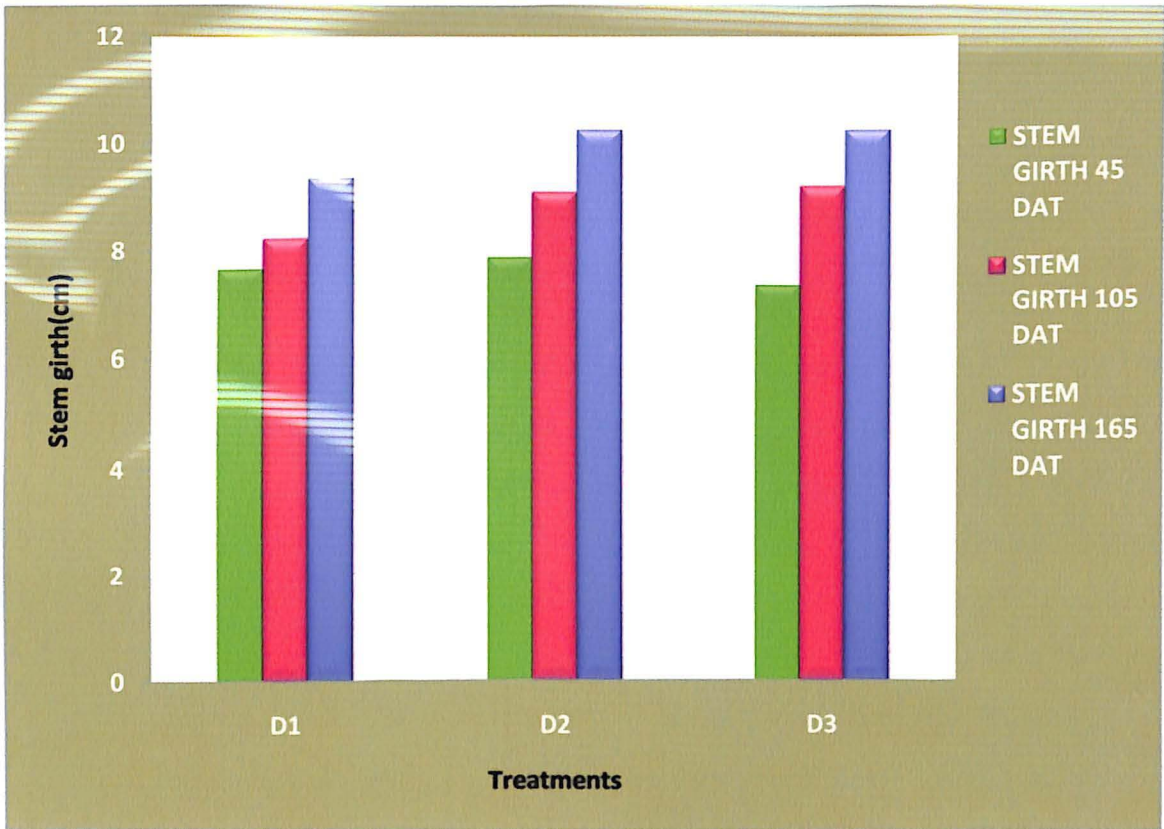
**Table 7: Effect of planting date, spacing and their interaction on Number of suckers per plant**

Treatment	Number of suckers per plant		
	45 DAT	105 DAT	165 DAT
<b>Planting Date (D)</b>			
D <sub>1</sub>	1.51	2.41	2.85
D <sub>2</sub>	1.23	2.30	3.63
D <sub>3</sub>	0.80	1.31	1.96
SE(m) <sub>±</sub>	0.13	0.16	0.17
CD at 5%	0.38	0.47	0.51
<b>Spacing (S)</b>			
S <sub>1</sub>	0.77	1.35	1.97
S <sub>2</sub>	1.11	1.91	2.64
S <sub>3</sub>	1.33	2.26	3.18
S <sub>4</sub>	1.51	2.51	3.45
SE(m) <sub>±</sub>	0.15	0.19	0.20
CD at 5%	0.44	0.55	NS
<b>Interaction (DxS)</b>			
D <sub>1</sub> S <sub>1</sub>	1.06	1.73	1.93
D <sub>1</sub> S <sub>2</sub>	1.60	2.40	2.80
D <sub>1</sub> S <sub>3</sub>	1.60	2.60	3.06
D <sub>1</sub> S <sub>4</sub>	1.80	2.93	3.60
D <sub>2</sub> S <sub>1</sub>	0.66	1.40	2.46
D <sub>2</sub> S <sub>2</sub>	1.13	2.26	3.46
D <sub>2</sub> S <sub>3</sub>	1.40	2.60	4.26
D <sub>2</sub> S <sub>4</sub>	1.73	2.93	4.33
D <sub>3</sub> S <sub>1</sub>	0.60	0.93	1.53
D <sub>3</sub> S <sub>2</sub>	0.60	1.06	1.66
D <sub>3</sub> S <sub>3</sub>	1.00	1.60	2.23
D <sub>3</sub> S <sub>4</sub>	1.00	1.66	2.43
SE(m) <sub>±</sub>	0.26	0.33	0.35
CD at 5%	NS	NS	NS

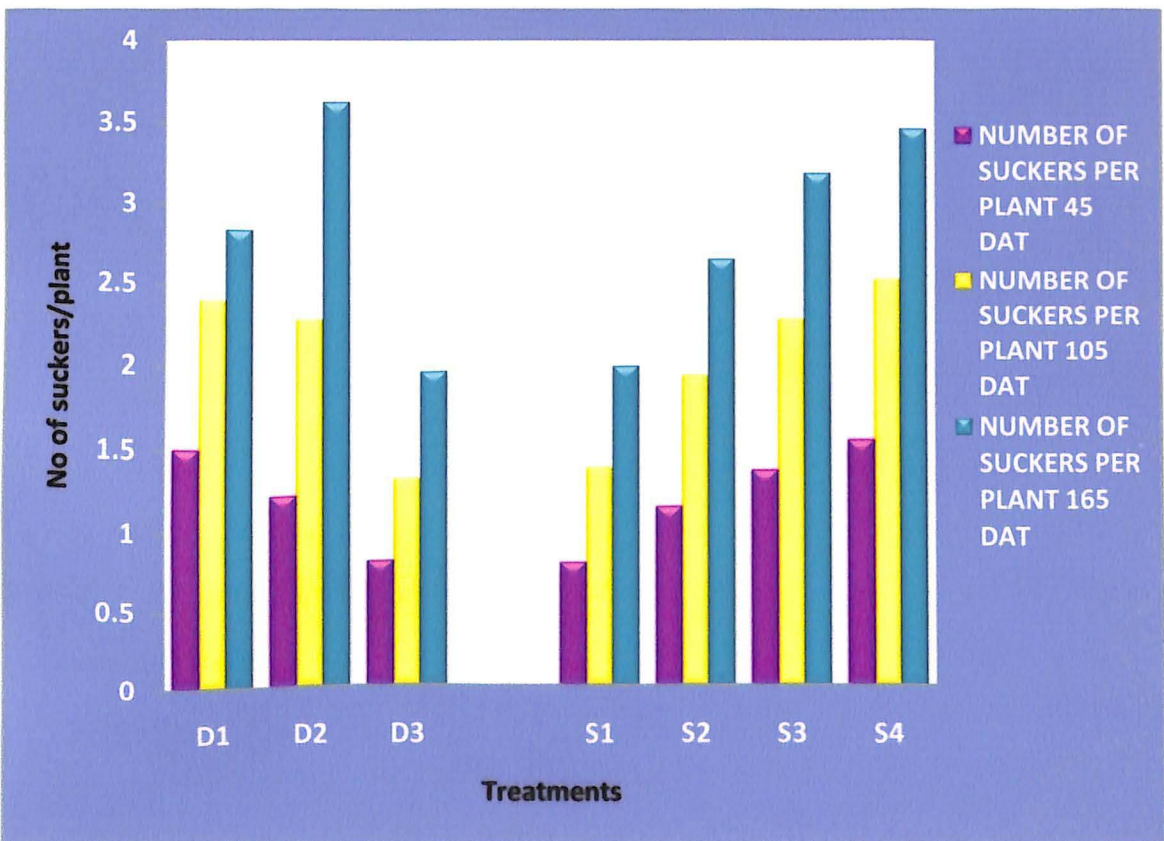
D<sub>1</sub>- 20<sup>th</sup> August planting  
D<sub>2</sub>- 20<sup>th</sup> September planting  
D<sub>3</sub>- 20<sup>th</sup> October planting

S<sub>1</sub>- 40x30 cm  
S<sub>2</sub>- 40x40 cm  
S<sub>3</sub>- 60x30 cm  
S<sub>4</sub>- 60x40 cm

NS- Non significant



**Fig.4 Effect of planting date on stem girth**



**Fig.5 Effect of planting date and spacing on number of suckers per plant**

The lowest (1.35 nos.) was produced in plants grown at 40x30 cm spacing. At 165 DAT, the highest value (3.45) for number of suckers was also observed at a spacing of 60x40 cm while the lowest (1.97) was recorded with 40x30 cm spacing. However, various spacings could not influence the sucker production at 165 DAT as observed in the present study.

The combination of planting date and spacing had no significant influence on the number of suckers. However, at 45 DAT plants under August planting with a spacing of 60x40 cm resulted in highest number of suckers (1.80), whereas those planted in October with spacing of 40x30 cm and 40x40 cm recorded the minimum (0.60). At 105 DAT, number of suckers was highest (2.93) in August and September planting both with a spacing of 60x40cm (D<sub>1</sub>S<sub>4</sub> & D<sub>2</sub>S<sub>4</sub>) and was lowest (0.93) in October planting with a spacing of 40x30 cm. At 165 DAT, plants under September planting with a spacing of 60x40 cm resulted in highest number of suckers (4.33), whereas those planted in October with a spacing of 40x30 cm recorded the minimum (1.53).

## **4.2 EFFECT OF PLANTING DATE AND SPACING ON FLOWERING COMPONENTS**

### **4.2.1 Days taken for initiation of flower panicle**

Observations recorded on days taken for initiation of flower panicle from the date of planting were statistically analyzed and the data so obtained are presented in Table 8 and Fig. 6.

As indicated from the Table 8, various planting dates influenced the days taken for initiation of flower panicle significantly. Initiation of flower panicle was the earliest in August planting followed by September planting which took 76.28 days and 117.90 days for the same respectively. On the other hand, it was maximum delayed in October planting which took 120.30 days for the same.

Different spacings also influenced the days taken for initiation of flower panicle significantly. Plants grown at a spacing of 40x30 cm took significantly less time (99.86 days) for flower panicle initiation whereas maximum time (109.88 days) was taken for the same by the plants grown at a spacing of 60x40 cm.

The interaction of planting date and spacing was found significant in influencing the days taken for initiation of flower panicle. Plants under September planting with a spacing of 60x40 cm ( $D_2S_4$ ) took maximum number of days for initiation of flower panicle (126.73 days) followed by those under October planting with a spacing of 60x40 cm (124.93 days) without showing significant variation from each other. On the other hand, plants under August planting with a spacing of 40x30 cm ( $D_1S_1$ ) took minimum time (74.93 days) and it was followed by and at par with  $D_1S_2$  and  $D_1S_3$  which took 75.86 days and 76.33 days, respectively for flower panicle initiation.

#### 4.2.2 Number of panicles per clump

Data on number of flower panicles produced per clump as influenced by various treatments and their combinations have been analyzed and presented in Table 8 and Fig. 7.

It was found that number of panicles produced per clump was significantly influenced by different planting dates. September planting resulted in highest number of panicles per clump (3.65) which differed significantly from other planting dates. It was followed by October planting (3.00) whereas least number of panicles (2.48) were produced in plants under August planting. However, number of panicles under October and August planting did not show any significant variation from each other.

Various spacings also had significant effect on number of panicles per clump. The highest number of panicles per clump (3.57) were recorded at a spacing of 60x40 cm and it was followed by the same produced at a spacing of 60x30 cm which recorded 3.06 panicles per clump without showing significant variation from each other. The lowest number (2.57) was recorded at 40x30 cm spacing which was at par with 40x30 cm and 60x30 cm spacing as observed in the present study.

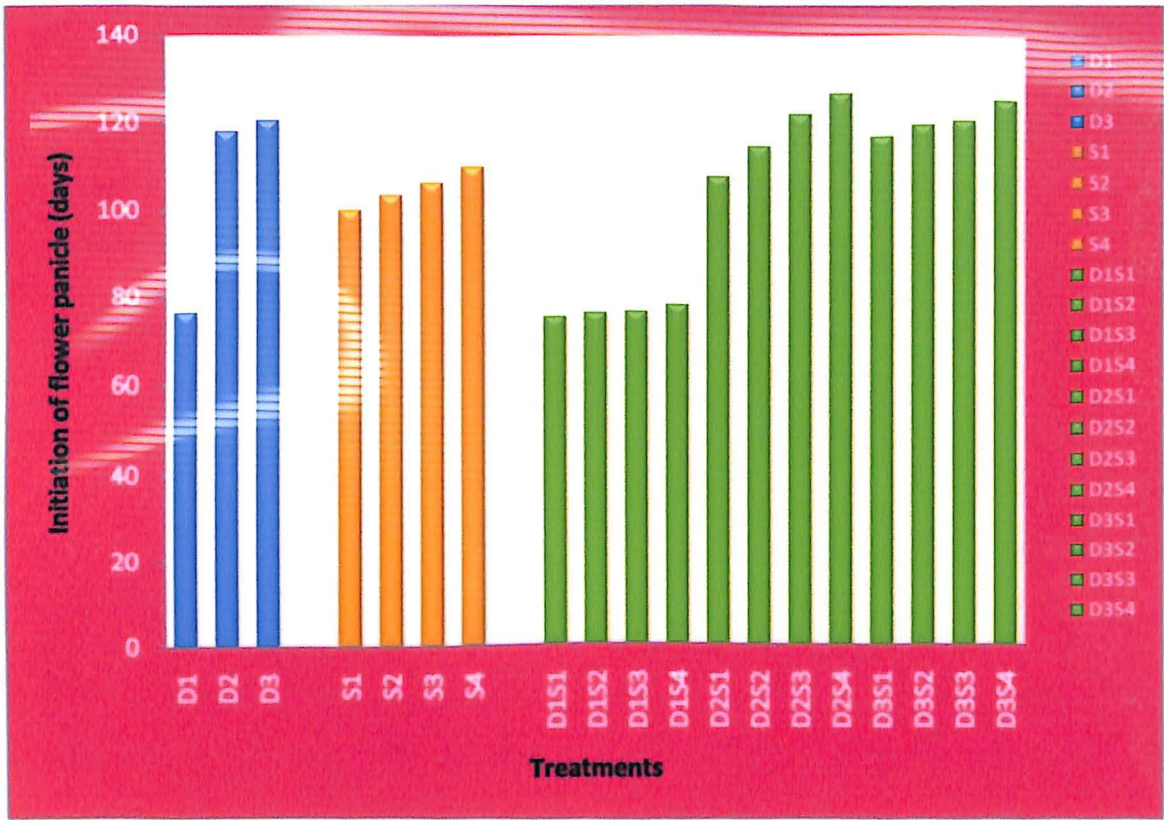
**Table 8: Effect of planting date, spacing and their interaction on Days taken for initiation of flower panicle, Number of panicles per clump, Length of flower panicle, Number of primary branches per panicle.**

Treatment	Days taken for initiation of flower panicle	Number of panicles per clump	Length of flower panicle (cm)	Number of primary branches per panicle
<b>Planting Date (D)</b>				
D <sub>1</sub>	76.28	2.48	43.70	17.43
D <sub>2</sub>	117.90	3.65	53.01	23.10
D <sub>3</sub>	120.30	3.00	45.52	20.53
SE(m) <sub>±</sub>	0.41	0.19	0.16	0.85
CD at 5%	1.20	0.56	0.48	2.46
<b>Spacing (S)</b>				
S <sub>1</sub>	99.86	2.57	48.88	18.00
S <sub>2</sub>	103.33	2.95	48.38	20.22
S <sub>3</sub>	106.22	3.06	46.94	21.15
S <sub>4</sub>	109.88	3.57	45.45	22.04
SE(m) <sub>±</sub>	0.48	0.22	0.19	0.98
CD at 5%	1.38	0.65	0.55	2.84
<b>Interaction (DxS)</b>				
D <sub>1</sub> S <sub>1</sub>	74.93	2.26	45.66	15.53
D <sub>1</sub> S <sub>2</sub>	75.86	2.33	45.06	16.86
D <sub>1</sub> S <sub>3</sub>	76.33	2.33	43.54	18.53
D <sub>1</sub> S <sub>4</sub>	78.00	3.00	40.54	18.80
D <sub>2</sub> S <sub>1</sub>	107.93	3.00	54.28	21.33
D <sub>2</sub> S <sub>2</sub>	114.80	3.53	53.80	22.86
D <sub>2</sub> S <sub>3</sub>	122.13	3.66	52.50	23.26
D <sub>2</sub> S <sub>4</sub>	126.73	4.40	51.44	24.93
D <sub>3</sub> S <sub>1</sub>	116.73	2.46	46.69	17.13
D <sub>3</sub> S <sub>2</sub>	119.33	3.00	46.28	20.93
D <sub>3</sub> S <sub>3</sub>	120.20	3.20	44.77	21.66
D <sub>3</sub> S <sub>4</sub>	124.93	3.33	44.36	22.40
SE(m) <sub>±</sub>	0.83	0.39	0.33	1.70
CD at 5%	2.40	NS	0.96	NS

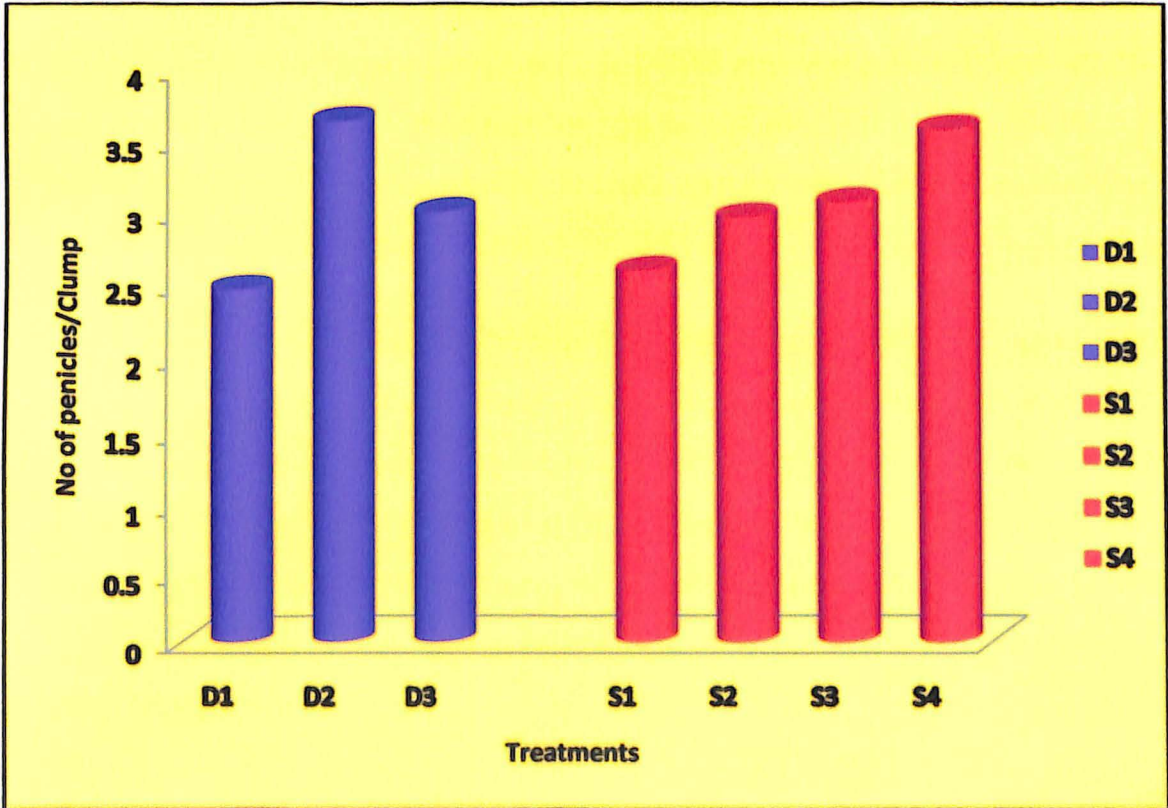
D<sub>1</sub>- 20<sup>th</sup> August planting  
D<sub>2</sub>- 20<sup>th</sup> September planting  
D<sub>3</sub>- 20<sup>th</sup> October planting

S<sub>1</sub>- 40x30 cm  
S<sub>2</sub>- 40x40 cm  
S<sub>3</sub>- 60x30 cm  
S<sub>4</sub>- 60x40 cm

NS- Non significant



**Fig.6 Effect of planting date, spacing and their interaction on days taken for initiation of flower panicle**



**Fig.7 Effect of planting date and spacing on number of panicles per clump**

The combination of planting date and spacing did not have any significant influence on number of panicles per clump. However, plants under September planting with a spacing of 60x40 cm ( $D_2S_4$ ) resulted in highest number of panicles per clump (4.40), whereas those planted in August with a spacing of 40x30 cm ( $D_1S_1$ ) recorded the minimum (2.26).

#### 4.2.3 Length of flower panicle

Observations on length of flower panicle as influenced by different planting dates and spacings as well as their combinations were recorded at 150 days after transplanting (DAT) and the data so obtained are presented in Table 8 Fig.8.

Length of flower panicle was significantly influenced by planting dates. September planting ( $D_2$ ) resulted in highest value (53.01 cm) for length of flower panicle followed by October planting (45.52 cm) whereas the least (43.70 cm) was recorded in August planted crop.

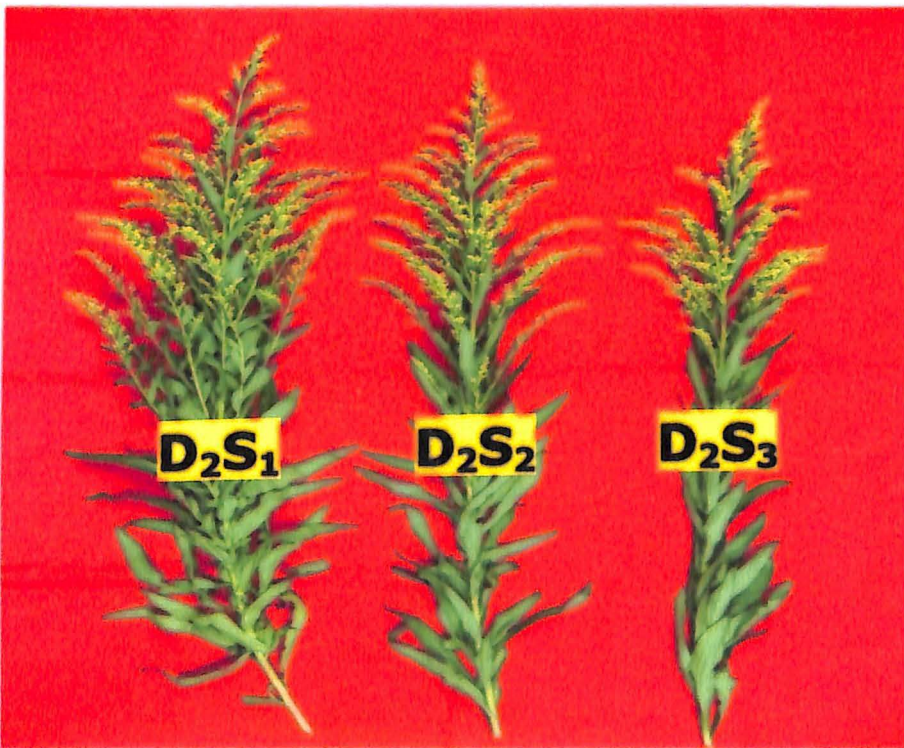
Different spacings also influenced the length of flower panicle significantly. The longest flower panicle (48.88 cm) was resulted from 40x30 cm spacing which was followed by and at par (48.38cm) with 40x40 cm spacing. On the other hand, the shortest (45.45 cm) flower panicle was recorded at 60x40 cm spacing ( $S_4$ ).

Interaction effect of planting date and spacing also had significant influence over the length of flower panicle. September planting with a spacing of 40x30 cm ( $D_2S_1$ ) resulted in longest flower panicle (54.28 cm) and it was followed by the same recorded under September planting with 40x40 cm spacing (53.80 cm) without showing any significant variation from each other. The shortest (40.54 cm) flower panicle was recorded under August planting with 60x40 cm spacing ( $D_1S_4$ ).



**Plate 4. Effect of planting date on length of flower panicle**

**Plate 5. Effect of spacing on length of flower panicle**



**Plate 6. Effect of interaction of planting date and spacing on length of flower panicle**

#### 4.2.4 Number of primary branches per panicle

Observations were recorded on number of primary branches per flower panicle as influenced by various planting dates and spacings as well as their combinations at 150 DAT and the data so obtained were analyzed statistically and presented in the Table 8 and Fig. 9.

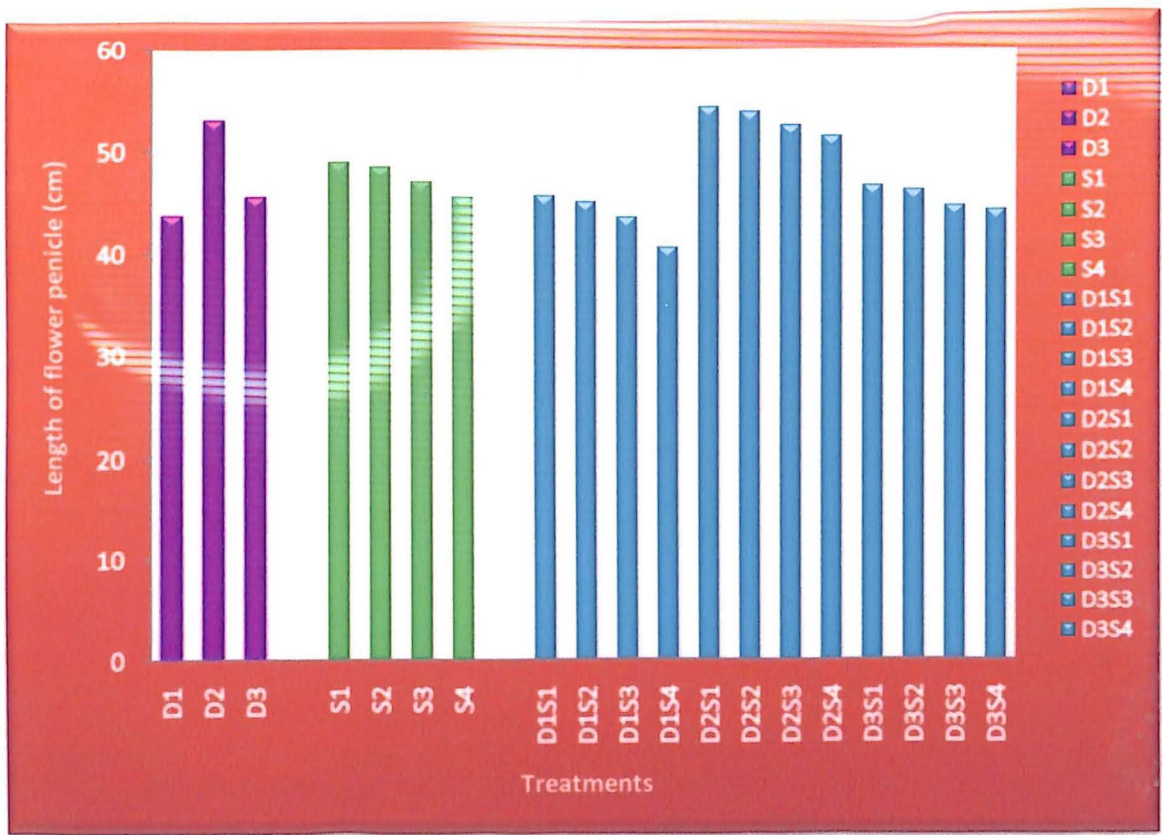
The data revealed that various planting dates influenced the number of primary branches per panicle significantly. Highest value (23.10) for number of primary branches per panicle was recorded in September planting followed by October planting (20.53) and it was lowest (17.43) in case of August planting.

Number of primary branches per panicle was also significantly influenced by different levels of spacing. Plants grown at a spacing of 60x40 cm ( $S_4$ ) produced highest number of primary branches per panicle (22.04) followed by those produced at 60x30 cm ( $S_3$ ) and 40x40 cm ( $S_2$ ) which recorded 21.15 and 20.22 number of branches per panicle respectively and these three were at par with each other. On the other hand, the lowest number (18.00) was recorded with a spacing of 40x30 cm ( $S_1$ ). However, it was at par with 40x40 cm ( $S_2$ ) spacing.

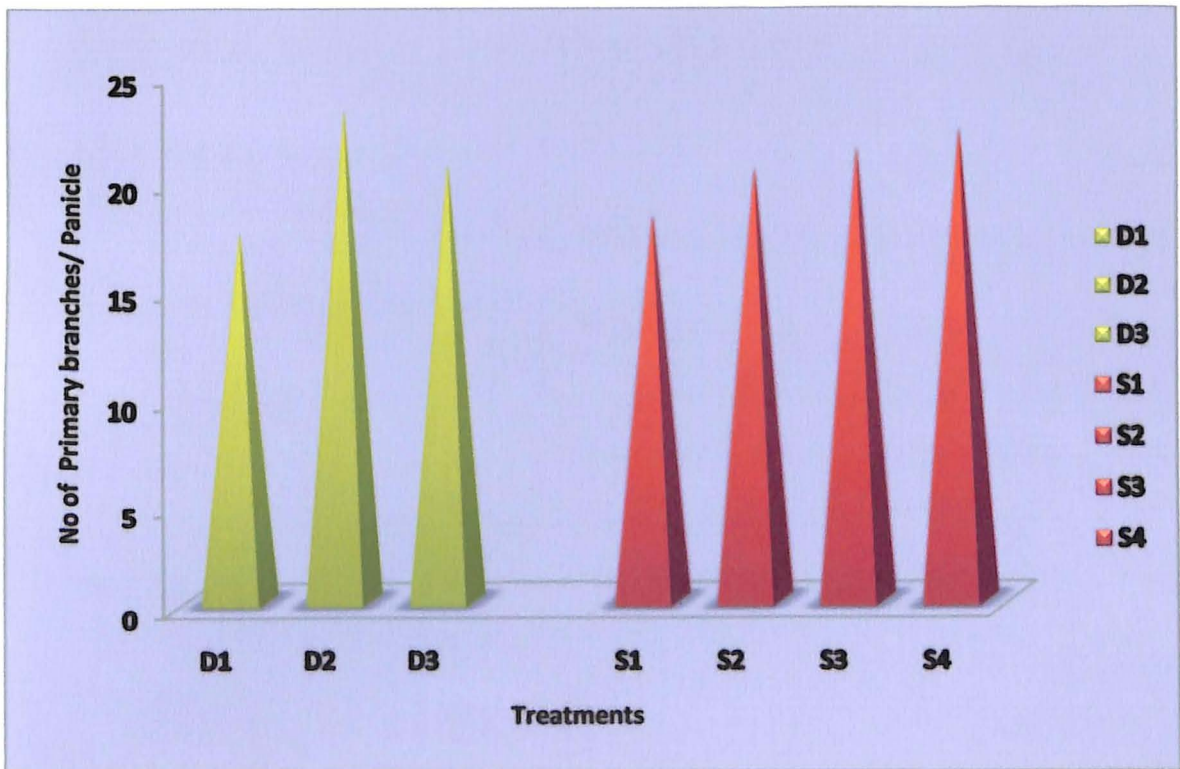
Interaction of planting date and spacing had no significant effect on number of primary branches per panicle. However, plants under September planting with a spacing of 60x40 cm ( $D_2S_4$ ) recorded the maximum value (24.93) for number of primary branches per panicle, whereas, those planted in August with a spacing of 40x30 cm ( $D_1S_1$ ) recorded the minimum (15.53).

#### 4.2.5 Spread of primary branches of panicle

Observations were recorded on spread of primary branches of flower panicle in goldenrod as influenced by planting dates, spacing and their interaction. The data so obtained were subjected to statistical analysis and are presented in Table 9 and Fig. 10.



**Fig.8 Effect of planting date, spacing and their interaction on length of flower panicle**



**Fig.9 Effect of planting date and spacing on number of primary branches per panicle**

It can be seen from the Table 9 that different planting dates had significant influence on spread of primary branches of flower panicle of goldenrod. October planting resulted in highest value (24.97 cm) for spread of primary branches of panicle followed by September planting (22.66 cm) and these two were at par with each other. On the other hand, the lowest value (18.23 cm) was recorded under August planting.

Various levels of spacing also influenced the spread of primary branches of panicle significantly. Highest spread (23.71 cm) was recorded with a spacing of 60x40 cm followed by those recorded with 60x30 cm (23.32 cm) and 40x40 cm (21.17 cm) spacings without showing significant variation from each other, whereas the lowest spread (19.61 cm) was recorded at 40x30 cm spacing. However, it was at par with the same recorded with 40x40 cm spacing.

The combination of planting date and spacing had no significant effect on the spread of primary branches of panicle. However, October planted crop with a spacing of 60x40 cm recorded the highest value (26.80 cm), whereas those planted in August with a spacing of 40x30 cm recorded the lowest value (16.60 cm) for the spread of primary branches of panicle.

#### **4.2.6 Days taken for first flowering**

Data pertaining to days taken for first flowering as influenced by various treatments and their combinations are presented in Table 9 and Fig. 11.

Days taken for first flowering was influenced significantly by different planting dates tried. Appearance of flower was earliest in August planted crop which took 90.96 days for the same and differed significantly from other planting dates. On the other hand, maximum delay for first flowering was noticed in October planted crop which took 139.91 days for the same.

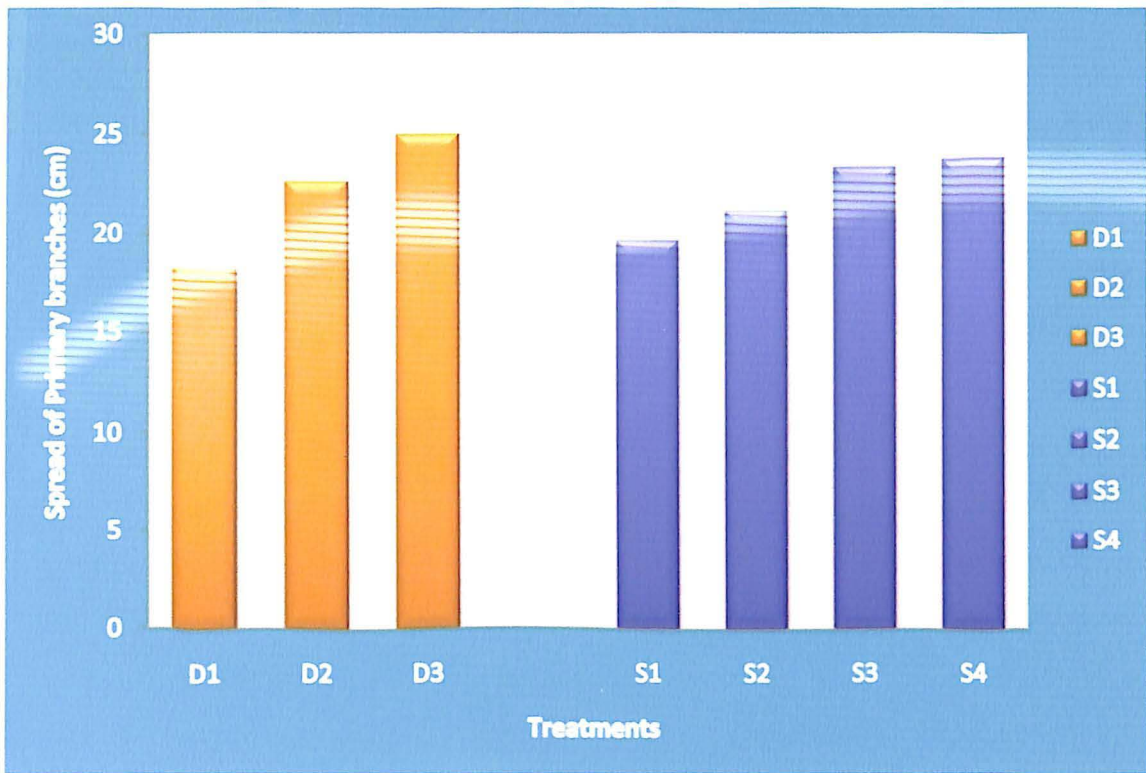
**Table 9: Effect of planting date, spacing and their interaction on Spread of primary branches of panicle, Days taken for first flowering, Rachis length, Longevity of flower stalk in the field.**

Treatment	Spread of primary branches of panicle (cm)	Days taken for first flowering	Rachis length (cm)	Longevity of flower stalk in the field
<b>Planting Date (D)</b>				
D <sub>1</sub>	18.23	90.96	39.12	4.46
D <sub>2</sub>	22.26	138.48	47.39	4.53
D <sub>3</sub>	24.97	139.91	38.52	4.65
SE(m) <sub>±</sub>	0.86	0.29	0.27	0.10
CD at 5%	2.48	0.86	0.78	NS
<b>Spacing (S)</b>				
S <sub>1</sub>	19.61	119.53	43.86	4.17
S <sub>2</sub>	21.17	121.02	42.22	4.31
S <sub>3</sub>	23.32	124.84	40.99	4.62
S <sub>4</sub>	23.71	127.08	39.64	5.08
SE(m) <sub>±</sub>	0.99	0.34	0.31	0.12
CD at 5%	2.87	0.99	0.90	0.35
<b>Interaction (DxS)</b>				
D <sub>1</sub> S <sub>1</sub>	16.60	89.13	40.77	4.06
D <sub>1</sub> S <sub>2</sub>	16.86	89.73	40.54	4.46
D <sub>1</sub> S <sub>3</sub>	19.46	91.66	39.05	4.53
D <sub>1</sub> S <sub>4</sub>	20.00	93.33	36.11	4.80
D <sub>2</sub> S <sub>1</sub>	20.80	131.26	51.18	4.20
D <sub>2</sub> S <sub>2</sub>	21.40	134.66	46.84	4.13
D <sub>2</sub> S <sub>3</sub>	24.10	143.93	45.77	4.46
D <sub>2</sub> S <sub>4</sub>	24.34	144.06	45.77	5.33
D <sub>3</sub> S <sub>1</sub>	21.44	138.20	39.62	4.26
D <sub>3</sub> S <sub>2</sub>	25.25	138.66	39.29	4.33
D <sub>3</sub> S <sub>3</sub>	26.40	138.93	38.14	4.86
D <sub>3</sub> S <sub>4</sub>	26.80	143.86	37.03	5.13
SE(m) <sub>±</sub>	1.72	0.59	0.54	0.21
CD at 5%	NS	1.73	1.57	NS

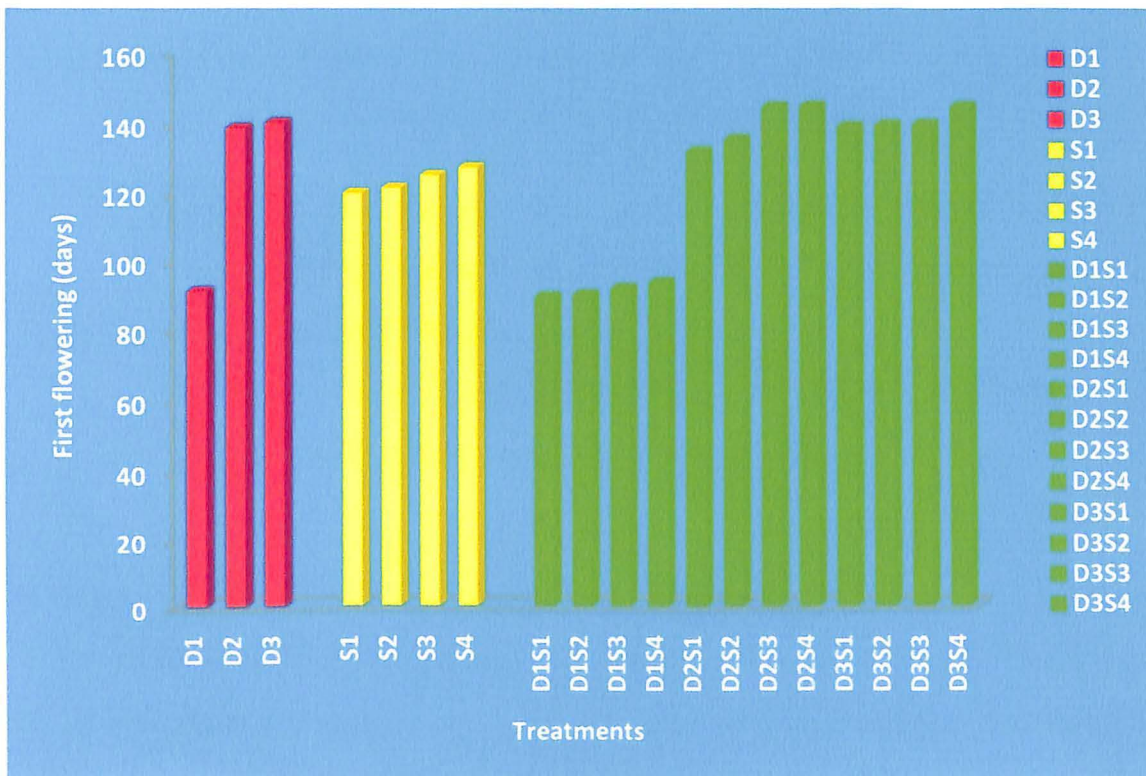
D<sub>1</sub>- 20<sup>th</sup> August planting  
D<sub>2</sub>- 20<sup>th</sup> September planting  
D<sub>3</sub>- 20<sup>th</sup> October planting

S<sub>1</sub>- 40x30 cm  
S<sub>2</sub>- 40x40 cm  
S<sub>3</sub>- 60x30 cm  
S<sub>4</sub>- 60x40 cm

NS- Non significant



**Fig.10 Effect of planting date and spacing on spread of primary branches per panicle**



**Fig.11 Effect of planting date, spacing and their interaction on days taken for first flowering**

Various spacings also had significant influence on the days taken for first flowering. At a spacing of 60x40 cm, the value for days taken for first flowering was highest (127.08) whereas it was lowest (119.53) at a spacing of 40x30 cm.

The interaction effect of planting date and spacing also had significant influence on the days taken for first flowering. September planted crop with a spacing of 60x40 cm ( $D_2S_4$ ) took maximum number of days (144.06) for first flowering which was followed by other treatment combinations like  $D_2S_3$  (143.93 days) and  $D_3S_4$  (143.86 days) without showing significant variation from each other. On the other hand minimum number of days for first flowering (89.13 days) were taken by the August planted crop grown at a spacing of 40x30 cm ( $D_1S_1$ ). However, it was at par with ( $D_1S_2$ ) which took 89.73 days for the same.

#### 4.2.7 Rachis length

Observations on rachis length as influenced by various treatments and their combinations were recorded and the data so obtained were subjected to statistical analysis and are presented in Table 9 and Fig. 12.

Date of planting had significant effect on the rachis length. September planting recorded the highest rachis length (47.39 cm) which differed significantly from other planting dates with respect to this floral character. On the other hand, it was the least (38.52 cm) in case of October planted crop. However, it remained at par with August planted crop with a value of 39.12 cm.

Spacing also had significant effect on the rachis length. Longest rachis (43.86 cm) was resulted from 40x30 cm spacing followed by 40x40 cm spacing (42.22 cm) which showed no significant variation from each other, whereas the shortest rachis (39.64 cm) was recorded at a spacing of 60x40 cm.

Interaction of planting date and spacing also had significant influence on the rachis length. Longest rachis (51.18 cm) was resulted from those planted in September with a spacing of 40x30 cm ( $D_2S_1$ ) and it was followed by the same recorded under  $D_2S_2$ ,  $D_2S_3$  and  $D_2S_4$  combination with a value of 46.84, 45.77 and 45.77 respectively without showing significant variation from each other. Rachis length was observed to be minimum (36.11 cm) in August planted crop grown at a spacing of 60x40 cm ( $D_1S_4$ ). However, it was at par with  $D_3S_4$  combination which recorded a value of 37.03 cm.

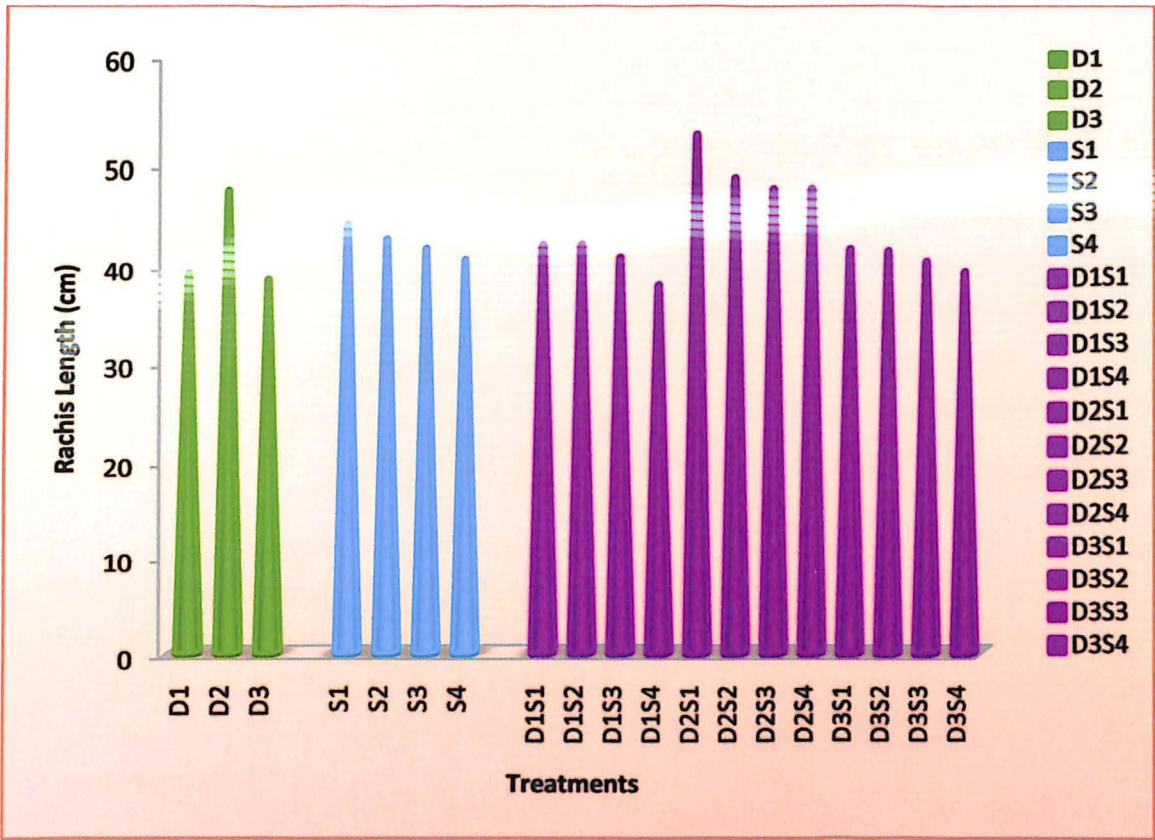
#### 4.2.8 Longevity of flower panicle in the field

Data recorded on longevity of flower panicle in the field as influenced by date of planting, spacing and their combination are presented in Table 9 and Fig. 13.

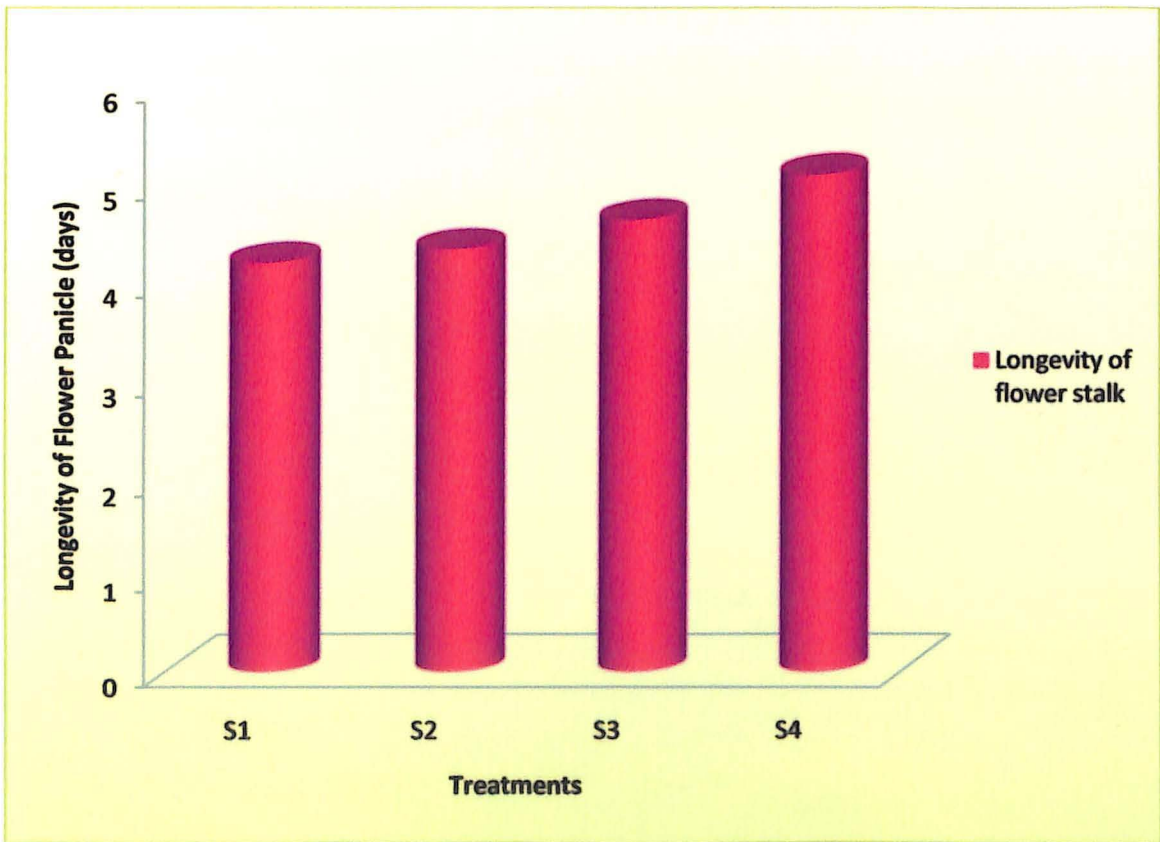
The result of the study revealed that various planting dates under trial could not influence the longevity of flower panicle in the field. However, the highest value (4.65 days) was recorded under October planting followed by September planting (4.53 days) while the lowest (4.46 days) was recorded under August planting.

Significant variation in longevity of flower panicle in the field was noticed due to various spacings under trial. Highest value (5.08 days) was recorded at a spacing of 60x40 cm, whereas the lowest value (4.17 days) was recorded with 40x30 cm spacing. However, it was at par with 40x40 cm spacing which recorded a value of 4.31 days.

Interaction of planting date and spacing had no significant effect on longevity of flower panicle in the field. However, the highest value (5.33 days) was recorded in September planting with 60x40 cm spacing ( $D_2S_4$ ), whereas lowest (4.06 days) was recorded in August planting with a spacing of 40x30 cm ( $D_1S_1$ ).



**Fig.12 Effect of planting date, spacing and their interaction on rachis length**



**Fig.13 Effect of spacing on longevity of flower stalk in the field**

#### 4.2.9 Yield of flower panicles per hectare

Data on number of flower panicles produced per clump as influenced by various treatments have been analyzed and presented in Table 10 and Fig.14.

It was found that yield of panicles per hectare was significantly influenced by different planting dates. September planting resulted in highest yield of panicles per hectare (169455.9 nos.) which differed significantly from other planting dates. It was followed by October planting (140192 nos.) whereas least yield of panicles (116081.8 nos.) was obtained from plants under August planting.

Various spacing also had significant effect on number of panicles per clump. The highest yield of panicles per clump (169730.2 nos.) was recorded at a spacing of 40x30 cm and it was followed by the same produced at a spacing of 40x40 cm which recorded 145508.9 nos. panicles per hectare. The lowest number (117786.9 nos.) was recorded at 60x40 cm spacing as observed in the present study.

The combination of planting date and spacing did not have any significant influence on yield of panicles per hectare. However, plants under September planting with a spacing of 40x30 cm ( $D_2S_1$ ) resulted in highest yield of panicles per hectare (197530.8 nos.), whereas those planted in August with a spacing of 60x30 cm ( $D_1S_3$ ) recorded the minimum (102423.4 nos.).

#### 4.3 Economics

The data on effect of interaction of planting date and spacing on economics of goldenrod crop is presented in appendix-II.

The economics was calculated for the closest spacing (40x30 cm) and the widest spacing (60x40 cm) in the month of September because plants performed better in this month irrespective of the spacing provided.

It can be seen from the appendix-II that though the yield of flower panicle was much higher in closest spacing of 40x30 cm, the benefit : cost ratio is higher (2.49) in case of widest spacing of 60x40 cm planted in September ( $D_2S_4$ ) as compared to 2.37 as obtained in closest spacing of 40x30 cm planted in the same month ( $D_2S_1$ ).

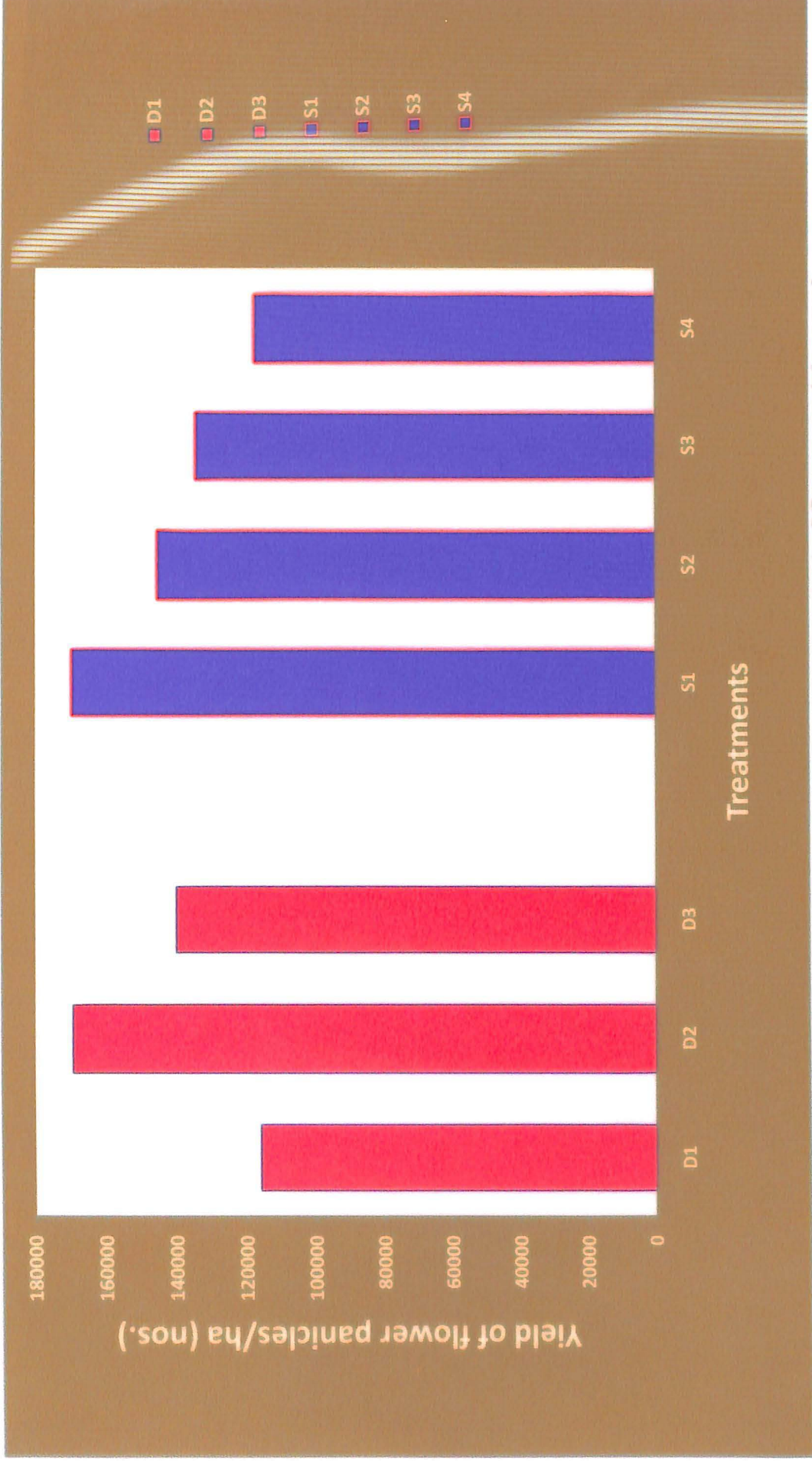
**Table 10: Effect of planting date, spacing and their interaction on yield of flower panicles per hectare**

Treatment	Yield of flower panicles/ha
<b>Planting Date (D)</b>	
D <sub>1</sub>	116081.8
D <sub>2</sub>	169455.9
D <sub>3</sub>	140192.0
SE(m) <sub>±</sub>	9889.6
CD at 5%	28555.1
<b>Spacing (S)</b>	
S <sub>1</sub>	169730.2
S <sub>2</sub>	145508.9
S <sub>3</sub>	134613.6
S <sub>4</sub>	117786.9
SE(m) <sub>±</sub>	11419.2
CD at 5%	32972.6
<b>Interaction (DxS)</b>	
D <sub>1</sub> S <sub>1</sub>	149245.5
D <sub>1</sub> S <sub>2</sub>	113893.0
D <sub>1</sub> S <sub>3</sub>	102423.4
D <sub>1</sub> S <sub>4</sub>	98765.4
D <sub>2</sub> S <sub>1</sub>	197530.9
D <sub>2</sub> S <sub>2</sub>	174485.6
D <sub>2</sub> S <sub>3</sub>	160951.1
D <sub>2</sub> S <sub>4</sub>	144856.0
D <sub>3</sub> S <sub>1</sub>	162414.3
D <sub>3</sub> S <sub>2</sub>	148148.1
D <sub>3</sub> S <sub>3</sub>	140466.4
D <sub>3</sub> S <sub>4</sub>	109739.4
SE(m) <sub>±</sub>	19779.2
CD at 5%	NS

D<sub>1</sub>- 20<sup>th</sup> August planting  
D<sub>2</sub>- 20<sup>th</sup> September planting  
D<sub>3</sub>- 20<sup>th</sup> October planting

S<sub>1</sub>- 40x30 cm  
S<sub>2</sub>- 40x40 cm  
S<sub>3</sub>- 60x30 cm  
S<sub>4</sub>- 60x40 cm

NS- Non significant



**Table 14. Effect of planting date and spacing on yield of flower panicles per ha.**

CHAPTER - V  
Discussion



## DISCUSSION

In any crop production programme including golden rod, growth and productivity are generally directly or indirectly influenced by both environmental factors as well as cultural practices followed. Any change in environmental conditions during different planting time has profound effect on crop growth and yield. The microclimate at the close vicinity of the plant exerts a considerable influence on crop performance with respect to various growth and flowering parameters. Plant spacing also plays an important role in manipulating the microclimate, by the inter and intra spacings provided, which means better crop growth and response to inputs as influenced by the change in plant metabolic activities. In addition, plant genotype, soil, cultural practices and their interaction also have profound influence on productivity of crops. However, it is not possible to manipulate the environment for better crop growth but one can manipulate the microclimate of the field to certain extent by adopting suitable cultural practices. Hence, an attempt has been made to enhance the performance of goldenrod by planting on different dates and manipulating the microclimate by providing different spacings to study its impact on growth and flower yield of golden rod. The results obtained from this investigation have been discussed in this chapter.

### 5.1 Effect of planting date

#### 5.1.1 Effect of planting date on vegetative growth characters:

The result of the study indicated that the height of the plants in goldenrod was significantly influenced by the date of planting at all stages of plant growth. At 45 and 105 DAT, significantly taller plants were observed in September planted crop followed by August planting and the shortest was observed under October planting. At 165 DAT, the highest value for plant height was also recorded under September planting which was followed by October planting while the lowest was observed under August planting.

So far as number of leaves per clump was concerned, although maximum number was observed under August planting followed by September planting at 45 and 105 DAT, ultimately maximum number of leaves were observed under September planting at 165 DAT and it was followed by August planting while the lowest number was observed in October planted crop at all stages of plant growth.

Stem girth was significantly influenced by different planting dates. At 45 DAT, it was highest under September planting while at 105 and 165 DAT, highest value for stem girth was recorded under October planting followed by September planting without showing any significant variation from each other, while the lowest was recorded under August planting.

Significant influence of planting date was also observed on sucker production in goldenrod. Although maximum number of suckers per plant were produced in August planted crop followed by September planting at 45 and 105 DAT, no significant variation was found between the two planting dates. However, significantly higher number of suckers per plant were produced under September planting followed by August planting at 165 DAT. On the other hand sucker production was minimum in October planted crop at all stages of plant growth.

Increase in plant height, number of leaves, stem girth and number of suckers in September planting may be due to favourable growing conditions which might have resulted in luxuriant growth of plants. Performance of August planting was next to September planting. A temperature range of 16<sup>0</sup>C (min.) to 37<sup>0</sup>C (max.) and relative humidity between 83.9 to 94.4% in the day time seemed to be optimum for better plant growth as observed in the present study.

However, according to Sharma (1984), planting of golden rod during spring and rainy season was more favourable for plant growth.

### 5.1.2 Effect of planting dates on floral characters:

The results of the study revealed that various planting dates also significantly influenced all the floral parameters under study in goldenrod. It was observed that initiation of flower panicle was the earliest in August planting followed by September planting which took 76.28 and 117.90 days or in other words approximately two and half months and four months respectively.

It is a well-known fact that light plays a significant role in flower bud differentiation which is a physiological process and it is accelerated by availability of more light intensity. As per the meteorological data (appendix-I) recorded during cropping season, it was found that availability of more bright sunshine hours (7.8 hours) with moderately high temperature i.e. 32.3<sup>0</sup>C (max.) and 18.1<sup>0</sup>C (min.) in the month of November 2011 as compared to January 2012 (5.9 BSH and 28<sup>0</sup>C-16.3<sup>0</sup>C temperature) when initiation of flower panicle was noticed in August and September planted crop respectively might have played a key role in early and late initiation of the same under August and September planting.

Other floral characters like number of panicles per clump, length of flower panicle and number of primary branches per panicle were observed to be significantly higher in September planted crop followed by October planting. Production of more number of suckers under September planting might have produced more number of flower panicles while increased height with more number of leaves under September planting have favoured production of more photosynthates thus improving length of flower panicles with more number of primary branches. Between August and October planted crops, plants under October planting exhibited greater height with thicker stems. Even with less number of leaves and suckers, their performance was better with respect to above floral characters as compared to August planting.

It was also observed that spread of primary branches of panicle was maximum (24.97 cm) under October planting which was followed by September planting (22.26 cm) whereas length of rachis was significantly higher under September planting followed by October planting. The reasons stated earlier for improvement of other floral parameters as mentioned above may be ascribed to better performance of plants under September and October planting with respect to these two floral parameters.

Days to first flowering is an important parameter which determines the time of harvest of flower panicles. In the present investigation it was observed that plants under August planting took significantly less number of days for first flowering as compared to other two planting dates whereas between these two dates, October planting took comparatively more time for the same than September planting. It has already been mentioned that initiation of flower panicle was earliest in August planted crop followed by September and October planting. Therefore it is obvious to expect the same sequence among the dates of planting with respect to days taken for first flowering in the plants.

No visible effect of planting dates was observed on longevity of flower panicle in the field condition. However, it was slightly higher (4.65 days) under October planting as compared to September (4.53 days) and August (4.46 days) planting.

Significant difference in yield of flower panicles was observed due to various dates of planting. Maximum yield (169455.9 panicles/ha) was recorded in September planted crop followed by the same recorded under October planting (140192 nos./ha) while the lowest (116081.8 nos./ha) was recorded under August planting. However, yield recorded under August and October planting showed no significant variation from each other. Since per hectare yield was computed from per plant yield, the same trend was noticed in both the cases.

## 5.2 Effect of spacing

### 5.2.1 Effect of spacing on vegetative growth parameters

Different levels of spacing had significant influence on various vegetative growth parameters in goldenrod.

Among various spacings adopted (viz., 40x30 cm, 40x40 cm, 60x30 cm and 60x40 cm), significantly taller plants were produced under closest spacing of 40x30 cm while the shortest plants were produced under widest spacing of 60x40 cm at all stages of plant growth. The result of the present study is in the same line as observed by Khobragade *et al.* (2012) in china aster who reported that closer spacing produced taller plants. Due to closer spacing there is increase in plant density per unit area due to which availability of sunlight might be a limiting factor as a result the plants might have grown taller for getting sufficient light to meet their requirement.

Significant difference in production of leaves per clump was also observed due to various spacings adopted at all stages of plant growth. The widest spacing of 60x40 cm resulted in production of maximum leaves per plant while the number was reduced with adoption of closer spacing and the minimum number was produced under the closest spacing of 40x30 cm. similar increase in leaf number was also recorded by Patel *et al.* (2002) and Malam *et al.* (2010) in spiderlily and tuberose respectively under wider spacing as compared to closer spacing.

Difference in the stem girth was also noticed due to different spacings adopted which followed the same trend as observed in case of leaves with maximum and minimum value reported under widest and closest spacing, respectively. This finding is in conformity with the result obtained by Samantaray *et al.* (1999) who found thicker stems under wider spacing in marigold. However, in the present study the difference was not significant.

Significantly more numbers of suckers per plant were also produced under widest spacing of 60x40 cm at 45 and 105 DAT which gradually reduced with adoption of closer spacings. Although the same trend was noticed with respect to sucker production at 165 DAT, the difference under various spacings was not significant. Increase in number of suckers per plant in goldenrod was also recorded by Sodha and Dhaduk (2002).

Better performance of plants with respect to various growth characters like number of leaves per plant, stem girth and number of suckers per plant may be attributed to congenial growing conditions like more space available for growth of roots and shoots. Proper spacing improves the availability of nutrients, aeration and light intensity (Ravindran *et al.*, 1986) which results in better crop growth and response to the inputs.

### **5.2.2 Effect of spacing on floral characters**

Different spacings had significant influence on various flowering components of goldenrod. It was observed that plants under closest spacing of 40x30 cm exhibited significantly earlier initiation of flower panicle while it was significantly delayed under widest spacing of 60x40 cm. It may be stated that under closer spacing plants could not get favourable growing environment and there was less scope for better vegetative growth due to which plants might have entered earlier into the reproductive phase as a result earlier initiation of flower panicle would have been expected under closer spacing.

The same trend was also noticed with respect to days taken for first flowering. As initiation of flower panicle was earlier under closer spacing, appearance of first flower was also observed to be earlier under this spacing. On the other hand, plants exhibited better vegetative growth under wider spacing and entered into the reproductive phase later. Hence, initiation of flower panicle as well as first flowering in the plant was delayed under wider spacing.

Significant influence of spacing on flowering components like number of panicles per clump and spread of primary branches in flower panicle was also observed in the present study which were found to be highest under widest spacing of 60x40 cm and decreased under closer spacing, recording the lowest value under closest spacing of 40x30 cm. However, number of panicles under 40x30 cm, 40x40 cm and 60x30 cm were statistically comparable with each other. Similarly, number and spread of primary branches in flower panicle under 60x40 cm, 60x30 cm and 40x40 cm as well as under 40x30 cm and 40x40 cm were found at par with each other.

Production of more number of leaves and suckers per plant with thicker stems under wider spacing might have resulted in production of more photosynthates which might have improved the above floral characters. Similar findings have been reported by Patel *et al.* (2002) and Dorajeerao *et al.* (2012) who observed more number of flower stalks per clump and increased number of flowers per plants in spiderlily and garland chrysanthemum, respectively under wider spacing as compared to closer spacing. Sodha and Dhaduk (2002) also recorded highest values for flowering attributes such as number of inflorescence branches, spread of inflorescence branches and number of panicles per plant in goldenrod under widest spacing.

Length of flower panicle as well as rachis length are two other important floral characters in goldenrod. Longest flower panicles with maximum length of rachis were produced under closest spacing of 40x30 cm which were reduced under wider spacings. However, the values in respect of these two parameters were statistically comparable under 40x30 cm and 40x40 cm spacing.

Reduction in planting distance increased the plant density per unit area as a result, plants exhibited more vertical growth in search of light and the vegetative as well as flowering shoots or panicles were more elongated under

closer spacing than wider spacing. Similar increase in flower stem length in Standard carnation was also observed by Kazaz *et al.* (2011) due to increase in planting density.

The result of the study also indicated that significant variation in longevity of flower panicle under field condition was also noticed due to various spacings adopted. It was found maximum under wider spacing of 60x40 cm while the minimum was recorded under closest spacing of 40x30 cm. However, the longevity of flower panicles under 40x30 cm and 40x40 cm spacing was statistically comparable with each other. Availability of congenial growing conditions like more space, better aeration and light intensity under wider spacing might have contributed for greater longevity of flower panicles. Reduction in vase life of standard carnation due to increase in plant density was also recorded by Kazaz *et al.* (2011).

Significant variation in flower yield was also observed due to various spacings adopted. Maximum yield of 169730.2 panicles per ha was recorded under closest spacing of 40x30 cm which was followed by and at par with 40x40 cm spacing (145508.9 nos./ha). On the other hand the lowest yield (117786.9 nos./ha) was recorded under widest spacing of 60x40 cm spacing. However, yield under 60x40 cm, 60x30 cm and 40x40 cm spacings were statistically comparable with each other.

Variation in plant population per unit area under different spacings resulted in variation in yield of flower panicles. Hence, higher yield was obtained under closer spacing with higher plant population.

### 5.3 Interaction effect of planting date and spacing

#### 5.3.1 Interaction effect of planting date and spacing on vegetative growth characters

Various combinations of planting date and spacing significantly influenced the plant height at all stages of plant growth. The tallest plants were observed in September planted crop grown at closest spacing of 40x30 cm ( $D_2S_1$ ) followed by the treatment combination of  $D_2S_2$ . However, at initial stages of growth i.e. 45 DAT, the height recorded under these two combinations were statistically comparable. It has already been discussed that plant height was maximum under September planting irrespective of spacing adopted. Similarly, irrespective of planting date it was maximum under closest spacing of 40x30 cm. Hence, the height of the plant might have further improved due to combined effect of above two treatments. Significantly shorter plants were recorded under  $D_3S_4$  combination at 45 and 105 DAT. However, at 165 DAT, the same was recorded under  $D_1S_4$  combination.

Significantly more number of leaves per clump were recorded under August planting with widest spacing of 60x40 cm ( $D_1S_4$ ) at all stages of plant growth. As already been pointed out, number of leaves under August planting as well as with widest spacing of 60x40 cm were maximum, their combined effect also exhibited similar effect on this growth parameter. The number of leaves per clump were minimum under  $D_3S_1$  combination. However, at 45 DAT, the leaf number recorded under  $D_3S_1$ ,  $D_2S_1$ ,  $D_3S_2$ ,  $D_3S_3$  and  $D_3S_4$  were statistically comparable with each other.

Various combinations of planting date and spacing could not influence the stem girth and number of suckers per plant significantly as observed in the present study.

### 5.3.2 Interaction effect of planting date and spacing on flowering components

Interaction of planting date with spacing had significant influence on days required for initiation of flower panicle. It was earliest in August planted crop at closest spacing of 40x30 cm ( $D_1S_1$ ). However, time taken for panicle initiation under  $D_1S_1$ ,  $D_1S_2$  and  $D_1S_3$  did not show any significant variation. On the other hand maximum delay in panicle initiation was observed under  $D_2S_4$ . However, it was at par with  $D_3S_4$  in this respect. Individual effect of August planting as well as closest spacing on days required for initiation of flower panicle which was observed to be earliest in the present study seemed to be the contributing factors for observing similar effect due to above treatment combination.

So far days to first flowering was concerned, more or less same trend was noticed due to various treatment combinations. Appearance of first flower was observed to be earliest in August planted crop grown at the closest spacing of 40x30 cm ( $D_1S_1$ ) which was closely followed by and at par with  $D_1S_2$  combination. On the other hand, maximum delay for first flowering was noticed in September planted crop grown at the widest spacing of 60x40 cm ( $D_2S_4$ ). However, the plants under  $D_2S_4$ ,  $D_2S_3$  and  $D_3S_4$  took more or less same time for the same without showing significant variation from each other.

Since initiation of flower panicle was earliest under  $D_1S_1$  and was maximum delayed under  $D_2S_4$ , it is obvious that appearance of first flower in the plant would follow the same trend under respective treatment combinations.

Various combinations of planting date and spacings also had significant influence on panicle and rachis length of golden rod. Maximum length for both the parameters were recorded under September planting combined with closest spacing of 40x30 cm ( $D_2S_1$ ) followed by the same recorded under  $D_2S_2$  combination. However, with respect to panicle length, both the treatment

combinations were at par with each other. On the other hand, the shortest length of panicle and rachis were recorded under August planting combined with widest spacing of 60x40 cm ( $D_1S_4$ ) which was followed by  $D_1S_3$  in respect of panicle length. However, rachis length under  $D_1S_4$  and  $D_3S_4$  were statistically comparable with each other. As observed in the present study, between the two factors viz., date of planting and spacing, the latter was found to have strong influence on panicle and rachis length. The treatment combinations with closer spacing (either  $S_1$  or  $S_2$ ) recorded more length of panicle and rachis as compared to wider spacing (either  $S_4$  or  $S_3$ ).

Floral characters like number of panicles per clump, number and spread of primary branches of panicle, longevity of flower panicle in the field and yield of flower panicles per ha were not significantly influenced by various combinations of planting date and spacing as observed in the present investigation.

CHAPTER - VI

Summary & Conclusion



## SUMMARY & CONCLUSION

The experiment entitled “Effect of planting date and spacing on growth and flower yield of golden rod (*Solidago canadensis* L.)” cv. Local yellow was carried out in the form of a field trial in the department of Floriculture and Landscaping, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar during the period of August, 2011 to June, 2012. The experiment was laid out in Factorial Randomized Block Design with three replications and consisted of two factors viz., planting date (3 dates i.e. 20<sup>th</sup> of August, September and October) spacing (4 levels i.e. 40x30 cm, 40x40 cm, 60x30 cm and 60x40 cm) as treatments. The results of the experiment are summarized in this chapter.

### **Effect of planting date on growth and flowering of golden rod:**

1. Plant height in golden rod was significantly influenced by various dates of planting at all stages of plant growth. The height was observed to be maximum under September planting while it was minimum under October planting at 45 and 105 DAT and with August planting at 165 DAT.
2. Significantly more number of leaves per clump was produced under August planting followed by September planting at 45 and 105 DAT while the maximum number was recorded under September planting followed by August planting at 165 DAT. On the other hand the lowest number was recorded under October planting.
3. Significant influence of planting date was also observed on stem girth of golden rod plants. Although at 45 DAT maximum and minimum stem girth were recorded under September and October planting respectively. Subsequently the same were recorded under September and August planting respectively. However, stem girth under September and

October planting were almost identical without showing any significant variation at later stages of growth.

4. Although sucker production under August and September planting were statistically comparable with each other at 45 and 105 DAT, at later stage significantly higher number of suckers per plant were produced under September planting. On the other hand the lowest number was produced under October planting.
5. Initiation of flower panicle in the plant was earliest in August planted crop while the maximum delay was noticed for the same under October planting.
6. Number of panicles per clump as well as length of flower panicle were significantly higher under September planting while the lowest values in respect of these parameters were recorded under August planting. However, number of panicles per clump under August and October planting were statistically comparable with each other.
7. Number of primary branches per flower panicle was significantly higher under September planting while the lowest number was recorded under August planting.
8. So far as spread of primary branches of flower panicle was concerned, maximum spread was noticed under October planting followed by September planting. However, spread under both the planting dates was statistically comparable with each other.
9. Plants under August planting took minimum number of days for first flowering while maximum delay was noticed for the same under October planting.
10. Flower panicles under September planting recorded significantly longer rachis while rachis length was observed to be almost identical under August and October planting.
11. Date of planting had no significant influence on longevity of flower panicles under field condition.

12. Maximum yield of flower panicles (169455.9 nos./ha) was recorded in September planted crop while the lowest (116081.8 nos./ha) was recorded under August planting.

**Effect of spacing on growth and flowering of golden rod:**

1. Significantly taller plants were produced in the plants grown at closest spacing of 40x30 cm while the shortest plants were observed at widest spacing of 60x40 cm at all stages of plant growth.
2. Significantly maximum number of leaves per clump was observed with widest spacing of 60x40 cm which gradually reduced with decrease in spacing and the lowest was recorded under closest spacing of 40x30 cm.
3. Although stem girth in golden rod plants recorded slightly higher value under widest spacing of 60x40 cm at all stages of growth, it was almost identical under all the spacings under trial.
4. Maximum number of suckers per plant were produced under widest spacing (60x40 cm) which gradually reduced with further reduction of spacing and the minimum was recorded under closest spacing of 40x30 cm at all stages of growth. However, at later stage sucker production under all levels of spacing was found almost identical.
5. Initiation of flower panicles in the plant was observed to be significantly earlier at closest spacing of 40x30 cm while maximum delay for the same was observed under widest spacing (60x40 cm).
6. Maximum number of flower panicles per clump were recorded under widest spacing of 60x40 cm which reduced with reduction of spacing and the least number was recorded under closest spacing of 40x30 cm. However, sucker production with 60x40 cm and 60x30 cm was statistically comparable with each other.
7. Longer flower panicles were produced in plants grown at closer spacings as compared to wider spacing. Although the length of panicle

was maximum under 40x30 cm spacing it was almost identical with the same recorded with 40x40 cm spacing.

8. Although maximum number of primary branches per panicle were recorded with widest spacing of 60x40 cm, it was statistically comparable with the same recorded with 60x30 cm and 40x40 cm spacing.
9. Spread of primary branches of panicle was also observed to be maximum under widest spacing of 60x40 cm. However, it was almost similar with the same recorded with 60x30 cm and 40x40 cm spacing. On the other hand the minimum was recorded with closest spacing of 40x30 cm.
10. Plants grown at closest spacing of 40x30 cm were earliest to flower while the flowering was significantly delayed under widest spacing of 60x40 cm.
11. Rachis length was found to be maximum under closest spacing of 40x30 cm which was followed by and at par with 40x40 cm spacing. On the other hand it was minimum with widest spacing of 60x40 cm.
12. Plants grown at widest spacing (60x40 cm) exhibited significantly higher longevity of flower panicle under field condition which was reduced with reduction of spacing levels and the lowest value was recorded with closest spacing of 40x30 cm. However, longevity of flower panicle with 40x30 cm and 40x40 cm spacing was almost identical.
13. Maximum yield of 169730.2 panicles per ha was produced with closest spacing of 40x30 cm followed by the same recorded with 40x40 cm spacing (145508.9 nos.) without showing any significant variation, while the lowest yield (117786.9 nos./ha) was recorded under widest spacing of 60x40 cm. However, yield under 60x40 cm and 40x40 cm spacings were statistically comparable with each other.

**Interaction effect of planting date and spacing on growth and flowering of golden rod:**

1. Plants under September planting with 40x30 cm spacing ( $D_2S_1$ ) recorded the maximum height at 45 and 105 DAT. However, subsequently at 165 DAT maximum height of plant was recorded in September crop grown at a spacing of 60x30 cm ( $D_2S_3$ ). However, it was almost identical with that recorded with those planted in August at a spacing of 60x40 cm ( $D_1S_4$ ).
2. Although at initial stage of observation, maximum number of leaves per clump was recorded under August planting with 60x40 cm spacing ( $D_1S_4$ ), subsequently the same was recorded under September planting with 60x40 cm spacing. On the other hand, the lowest was recorded under October planting with 40x30 cm spacing ( $D_3S_1$ ).
3. Growth parameters like stem girth and number of suckers produced per plant were not influenced significantly due to interaction of planting date with spacing adopted.
4. Initiation of flower panicles in the plant was earliest in August planted crop at a spacing of 40x30 cm. However, plants under  $D_1S_1$ ,  $D_1S_2$  and  $D_1S_3$  took more or less same time for panicle initiation. On the other hand, plants under September planting with 60x40 cm spacing ( $D_2S_4$ ) took maximum time for panicle initiation and it was almost identical with  $D_3S_4$  combination.
5. So far as panicle length was concerned, it was observed to be maximum under September planting with 40x30 cm spacing ( $D_2S_1$ ) closely followed by  $D_2S_2$  combination without showing any significant variation while the lowest value was recorded under August planting with 60x40 cm spacing ( $D_1S_4$ ).
6. First flowering was noticed to be earliest in August planted crop with closest spacing of 40x30 cm ( $D_1S_1$ ). However, the time taken for appearance of first flower was more or less similar under  $D_1S_1$  and  $D_2S_1$

combination. Maximum delay in appearance of first flower was noticed under September planting with widest spacing of 60x40 cm ( $D_2S_4$ ). However, other combinations like  $D_2S_3$ ,  $D_3S_4$  also exhibited more or less similar performance with respect to this floral character.

7. Significantly longer rachis was recorded under September planting with closest spacing of 40x30 cm ( $D_2S_1$ ) while the shortest rachis was produced under August planting with widest spacing of 60x40 cm ( $D_1S_4$ ). However, length of rachis was observed to be more or less identical with that produced under  $D_3S_4$  combination.
8. Various combinations of planting date and spacing could not influence the floral characters like number of panicles per clump, number and spread of primary branches per panicle as well as longevity of flower panicles under field condition.
9. The cost benefit ratio calculated for September planted crop with widest spacing of 60x40 cm was observed to be higher (2.49) as compared to that calculated for the same date of planting with closest spacing of 40x30 cm (2.37).

## CONCLUSION

Based on the results of the present study, it was concluded that 20<sup>th</sup> September was the most appropriate time for planting of golden rod. Several growth and floral parameters like plant height, number of leaves per clump, stem girth, number of suckers per plant, number of flower panicles per clump, length of panicle and rachis as well as number of primary branches per panicle were significantly improved under this planting date. However, panicle initiation and days to first flowering were earliest under August planting whereas, maximum delay of the same was noticed under October planting. On the other hand, maximum spread of primary branches of flower panicle was observed under October planting.

Among various spacings tried, plants under closest spacing of 40x30 cm exhibited significantly taller plants. Besides, initiation of flower panicle and appearance of first flower were earliest under this spacing. Plants under closest spacing (40x30 cm) also recorded maximum panicle and rachis length. On the other hand, number of leaves per plant, number of panicles per clump, number and spread of primary branches of flower panicle as well as longevity of flower panicle under field condition were higher under widest spacing of 60x40 cm. performance of plants under other spacings were in between closest and widest spacing.

September planting with closest spacing ( $D_2S_1$ ) exhibited longer panicle and rachis, while August planting with closest spacing ( $D_1S_1$ ) recorded earliest initiation of flower panicle and production of first flower. On the other hand, greater plant height with more number of leaves per clump was recorded under September planting with widest spacing of 60x40 cm. Besides, panicle initiation and first flowering were maximum delayed under this combination ( $D_2S_4$ ).

Based on overall performance of the plants under different planting date and spacing treatments, September planting with 60x40 cm spacing could be recommended for commercial cultivation of golden rod cv. Local yellow in and around Bhubaneswar which could give a cost: benefit ratio of 2.49.

# Bibliography

## BIBLIOGRAPHY

- Afzal, M., Ahmed, M.M., Shah, R.A. and Awan, B.M. (2000). Effect of different sowing times on performance of dahlia (*Dahlia variabilis*). *Pakistan Journal of Biological Sciences*. **3**(1): 150-152.
- Amjad, A. and Ahmad, I. (2012). Optimizing Plant Density, Planting depth and postharvest preservatives for *Lilium longifolium*. *Journal of Ornamental and Horticultural Plants*. **2**(1): 13-20.
- Anjum, M.A., Nawaz, A., Gul, S. and Naveed, F. (2007). Effect of various sucker sizes and planting times on flowering and vase-life of chrysanthemum. *Pakistan Journal of Agricultural Sciences*. **44**(3): 475-480.
- Barad, A.V., Revar, H.J. and Rajput, S.T. (2011). Effect of nitrogen levels and cuttings (main and ratoon) on golden rod (*Solidago canadensis* L.) during summer and rainy season planting. *Indian Journal of Horticulture*. **68**(3): 379-385.
- Basavarajeshwari, C., Patil and Nalawadi, U.G. (2003). Effect of planting time on growth and flower yield in gaillardia (*Gaillardia pulchella* Foug.). *National Symposium on Recent Advances in Indian Floriculture*. pp-4.
- Berimavandi, A.R., Hashemavadi, D., Ghaziani, M.V.F. and Kaviani, B. (2011). Effects of plant density and sowing date on the growth, flowering and quantity of essential oil of *Calendula officinalis* L. *Journal of Medicinal Plants Research*. **5**(20): 5110-5115.
- Bhat, Z.A., Paul, T.M. and Siddiqui, M.A.A. (2010). Influence of spacing and size on growth, development, flowering, corm and Production of Gladiolus (*Gladiolus grandiflorus*) cv. White Prosperity. *Research Journal of Agricultural Sciences*. **1**(3): 282-283.
- Bijimol, G. and Singh, A. K. (2001). Effect of spacing and nitrogen on flowering, flower quality and post-harvest life of gladiolus. *Journal of Applied Horticulture*. **3**: 48-50.

- Dalvi, N. V., Rangwala, A. D. and Joshi, G. D. (2008). Effect of spacing and graded levels of fertilizers on yield attributes of gladiolus. *Journal of Maharashtra Agriculture University*. **33**(2): 167-170.
- Daneshvar, M.H., and Heidari, M. (2011). Effect of Planting Distance and Cultivation Depth on Some Quantitative Traits of Narcissus (*Narcissus tazetta* L.) Cut Flower in Climatic Conditions of Khouzestan (Mollasani). *Journal of Horticulture Science (Agricultural Sciences and Technology)*. **25**(3): 304-309.
- Dhatt, K. K. and Kumar, R. (2007). Effect of planting time and spacing on plant growth, flowering and seed yield in *Coreopsis lanceolata* and *Coreopsis tinctoria*. *Journal of Ornamental Horticulture*. **10**(2): 105-109.
- Dhatt, K. K. and Kumar, R. (2008). Effect of planting time and planting density on plant growth and seed yield of *Gaillardia aristata*. *Environmental Ecology*. **26**(3A): 1314-1317.
- Dorajeerao, A. V. D., Mokashi, A. N., Patil, V. S., Venugopal, C. K., Lingaraju, S. and Koti R. V. (2012). Effect of plant spacing on yield and quality of garland chrysanthemum (*Chrysanthemum coronarium* L.). *Karnataka Journal of Agricultural Sciences*. **25**(2): 229-231.
- Dubey, R.K., Kumar, R. and Poonam. (2002). Effect of planting time and spacing on cosmos (*Cosmos sulphureus* Cav.). *Journal of Ornamental Horticulture, New Series*. **5**(2): 46-47.
- Grawal, H.S., Kumar, R. and Singh, H. (2004). Effect of nitrogen, planting time and pinching on flower production in chrysanthemum (*Dendratherma grandiflora* Ramat) cv. Flirt. *Journal of Ornamental Horticulture*. **7**(2): 196-199.
- Hugar, A.H., Rajanna, P.H., Patil, M.G. and Pampanna, Y. (2003). Effect of spacing and levels of nitrogen and phosphorus on growth, flower and seed yield of china aster (*Callistephus chinensis* Nees) cv. Kamini. *National Symposium on Recent Advances in Indian Floriculture*. pp-10.

- Kapczyńska, A. (2012). Effect of planting time on flowering of four *Lachenalia* cultivars. *Acta Horticulturae*. **937**:575-580
- Kazaz, S., Tekintas, F.E. and Askin, M.A. (2011a). Effect of planting density and system on growth and flowering of spray Carnations. *Journal of Cell and Plant Sciences*. **2**(2): 1-6.
- Kazaz, S., Tekintas, F.E. and Askin, M.A. (2011b). Effects of different planting systems and densities on yield and quality in standard Carnations. *Journal of Cell and Plant Sciences*. **2**(1): 19-23.
- Khalaj, M.A., Edrisi, B. and Amiri, M. (2012). Effect of Nitrogen and Plant Spacing on Nutrients Uptake, Yield and Growth of Tuberose (*Polianthes tuberosa* L.). *Journal of Ornamental and Horticultural Plants*. **2**(1): 45-54.
- Khobragade, R.K., Bisen, S.; Thakur, R.S. (2012). Effect of Planting Distance and Pinching on Growth, Flowering and Yield of China Aster (*Callistephus chinensis*.) cv. Poornima. *Indian Journal of Agricultural Sciences*. **82**(4): 334-339
- Kizil, S., Arslan, N., Ölmez-Bayhan, S. and Khawar, K.M. (2008). Effects of different planting dates on improving yield of *Fritillaria imperialis* L. and *Fritillaria persica* L. bulbs damaged by small narcissus fly (*Eumerus strigatus* Fallen). *African Journal of Biotechnology*. **7**(24): 4454-4458.
- Kumar, R. and Kaur, K. (2001). Effect of time of planting and nitrogen on coreopsis. *Journal of Ornamental Horticulture, New Series*. **4**(1): 57-58.
- Laskowska, H., Pogroszewska, E., Durlak, W. and Kozak, D. (2012). The effect of bulb planting time and type of mulch on the yield of *Allium aflatunense* Fedtsch. *Acta agrobotanica*. **65**(4): 117-122.
- Malam V.R., Singh S.P., Ahlawat T.R., Mathukia R.K. (2010). Effect of spacing and crop duration on growth and flowering in tuberose (*Polianthes tuberosa* Linn.) cv. Double. *Progressive Agriculture*. **10**(3): 131-133.

- Maniram; Virendra Pal; Singh, M. K.; Mukesh Kumar (2012). Response of different spacing and salicylic acid levels on growth and flowering of gladiolus (*Gladiolus grandiflora* L.). *Hort Flora Research Spectrum*. **1**(3): 270-273
- Manjusha, M.A.V., Patil, V.S. (2002). Effect of planting dates on gerbera. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-33.
- Mathew, B. and Shepherd, H. (2002). Effect of planting date on African marigold. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-33.
- Mishra, M., Mohapatra, A. and Mohanty, C.R. (2002). Effect of N, P and spacing on tuberose. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-55.
- Misra, H.; Singh, A. K. and Singh, O. P. (2000). Effect of bulb size and spacing on growth and flowering behaviour of tuberose (*Polianthes tuberosa* Linn.). *Advances in Plant Sciences*. **13**(2): 563-566.
- Nair, S.A. and Singh, D.R. (2004). Effect of Varieties and Spacing on Growth and Flowering of Gladiolus in Andamans. *Indian Journal of Horticulture*. **61**(3): 253-255
- Natarajan, K. and Vijayakumar, A. (2002). Effect of fertilizer and spacing on seed yield and quality in marigold cv. African Giant. *Advances in plant sciences*. **15** (2): 525-532.
- Patel, B.N., desai, J.R. and Patel, B.M. (2002). Influence of spacings and nitrogen level on spiderlily. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-48.
- Raju, D.V.S., Singh, K.P. and Swaroop K. (2006). Performance of French marigold (*Tagetes patula* L.) in different planting months under Delhi condition. *Journal of Ornamental Horticulture*. **9** (3): 215-217.
- Ramachandrudu, K. and Thangam, M. (2007), Effect of plant spacings on growth, flowering and corm production in gladiolus. *Journal of Ornamental Horticulture*. **10** (1): 67-68.

- Rao, C.C. and Reddy, K.M. (2002). Effect of planting dates on African marigold. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-34.
- Ravindran, D.V.L., Rao, R.R. and Reddy, E.N. (1986). Effect of spacing and nitrogen levels on growth, flowering and yield of African marigold (*Tagetes erecta* L.). *South Indian Horticulure*. **34**(5): 320-323.
- Rohidas, S. B.; Jature, S. D.; Barkule, S. R.; Shinde, S. J.; Nikam, A. V. (2010). Effect of spacing on flowering and vase-life of gladiolus. *Asian Journal of Horticulture*. **5** (2 ): 339-340
- Ryagi, Y.H. and Nalawadi, U.G. (1996). Effect of plant density and different nitrogen levels on yield and yield attributing characters of goldenrod. *Karnataka Journal of Agricultural Sciences*. **9** (1): 173-176.
- Samantaray, D., Mohanty, C.R. and Behera, T.K. (1999). Effect of planting time and spacing on growth and flower yield of marigold (*Tagetes erecta* L.) cv. African Yellow. *Indian Journal of Horticulture*. **56**(4): 382-385.
- Seghatoleslami , M.J. and Mousavi, G.R. (2009). The effects of sowing date and plant density on seed and flower yield of pot marigold (*Calendula officinalis* L.). *Acta Horticulturae*. **826**:371-376
- Sharma, A. K.; Chaudhary, S. V. S.; Bhatia, R. S.(2012). Effect of spacing and pinching on regulation of flowering in 'African' marigold' (*Tagetes erecta* Linn.) under submontane low hill conditions of Himachal Pradesh. *Progressive Agriculture*. **12** (2): 331-336
- Sharma, S. and Talukdar, M.C. (2002).Effect of time, spacing and depth of planting on gladiolus. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium*. pp-60.
- Sharma, S.P. (1989). *Solidago*, In: T.K. Bose and L.P. Yadav (eds) *Commercial Flower*, Naya Prakash, New Delhi,; pp-861.
- Shiva, K.N. and Dadlani, N.K. (2002).Effect of planting dates on the performance of gladiolus under polyhouse. *Proceedings of Abstract*,

*National Symposium on Indian Floriculture in the New Millennium.*  
pp-4.

- Singh, M.C., Abner, C., Sirohi, N.P.S., Hasan, M. and Singh, D.P. (2002). Effect of different sowing dates on *Helianthus annuus*. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium.* pp-41.
- Sodha, B.P. and Dhaduk, B.K. (2002). Effect of spacing and nitrogen on *Solidago*. College of Horticulture & Forestry, G.A.U., Navsari, India. *Journal of ornamental Horticulture (New Series)*.5(1): 63-64.
- Sreekanth, P., Padma, M., Chandrasekhar, R. and Madhulety, T.Y. (2006). Effect of planting time, spacing and nitrogen levels on yield and quality of African marigold (*Tagetes erecta* L.). *Journal of Ornamental Horticulture.* 9 (2): 97-101.
- Tingare, S.S., Patil, K.B., Ranshur, N.J., Todmal, S.M. and Musale, S.V. (2007). Effect of different spacings and nitrogen levels on growth and flower production of goldenrod (*Solidago canadensis* L.). *Asian Journal of Soil Science.* 2 (2): 86-90.
- Tomar, B.S. (2002). Effect of planting dates on seed yield in marigold. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium.* pp-74.
- Vasudev, H.S., Umashankar, N., Murthy, P.V. and Shivanna, M.B. (2006). Influence of fertilizer and spacing levels on growth of marigold in Mysore district. *Journal of Asian Horticulture.* 2 (3):218-221.
- Verma, V.K. and Sharma, Y.D. (2002). Effect of planting dates and nitrogen levels on carnation under protected cultivation. *Proceedings of Abstract, National Symposium on Indian Floriculture in the New Millennium.* pp-3.
- Werner, A.P. (1989). Individual Flowering Time in a Goldenrod (*Solidago canadensis*): Field Experiment Shows Genotype more Important than Environment. *American Journal of Botany.*76 (11): 1681-1688.

# Appendices

## APPENDICES

### Appendix – I Meteorological data during the cropping season (August, 2011 to June, 2012)

Year/Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days	BSH (hours)
	Max.	Min.	AM	PM			
Aug., 2011	33.2	26.2	98.3	84.3	419.5	24	3.1
Sept., 2011	31.3	29.7	95.2	80.3	279.1	17	3.3
Oct., 2011	33.4	23.9	92.8	59.9	57.0	6	7.6
Nov., 2011	32.3	18.1	89.0	39.9	----	----	7.8
Dec., 2011	29.0	16.0	83.9	39.7	----	----	5.4
Jan., 2012	28.7	16.3	90.7	51.4	44.4	3	5.9
Feb., 2012	33.2	16.9	89.2	39.4	----	----	7.8
Mar., 2012	37.4	22.9	94.4	34.2	----	----	6.7
Apr., 2012	38.2	24.3	84.8	49.9	85.9	5	6.4
May., 2012	39.3	27.2	88.2	44.3	12.2	2	7.9
Jun., 2012	37.6	26.8	87.9	60.8	116.6	11	3.0

**Appendix – II Cost of cultivation of golden rod for flower production  
for one hectare area grown at 40x30 cm (S<sub>1</sub>) & 60x40 cm (S<sub>4</sub>) spacings**

Sl. No.	Particulars	S <sub>1</sub>		S <sub>4</sub>	
		Unit	Cost (Rs.)	Unit	Cost (Rs.)
<b>A. Input</b>					
1.	Suckers @ 30p/sucker	65844	19753.2	32922	9876.6
2.	FYM @ 10t/ha (Rs.212/t)	10	2120	10	2120
3.	Chemical fertilizers				
	N <sub>2</sub> @ 12.00/kg	150	1800	150	1800
	P <sub>2</sub> O <sub>5</sub> @ 32.5/kg	100	3250	100	3250
	K <sub>2</sub> O @ 10.8/kg	100	1080	100	1080
4.	Plant protection		4500		4500
	<b>SUB TOTAL (A)</b>		<b>32503.2</b>		<b>22626.6</b>
<b>B. Labour &amp; Operation</b>					
1.	Land preparation	40 MD	3600	40 MD	3600
2.	Planting	50 MD	4500	50 MD	4500
3.	Interculture	60 MD	5400	60 MD	5400
4.	Fertilizer & Pesticide application	30 MD	2700	30 MD	2700
5.	Irrigation	50 MD	4500	50 MD	4500
6.	Harvesting	80 MD	7200	80 MD	7200
	<b>SUB TOTAL (B)</b>		<b>27900</b>		<b>27900</b>
	<b>GRAND TOTAL (A+B)</b>		<b>60403.2</b>		<b>50526.6</b>
<b>C. Yield</b>					
1.	Yield of flower panicle(nos.)	169730.2		117786.9	
2.	Cost of each flower panicle		1.20		1.50
3.	Gross income		203676.2		176680.3
4.	Net profit		143273.0		126153.7
5.	Benefit : cost ratio		2.37		2.49