Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching

THESIS

Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

AGRICULTURE

In

HORTICULTURE

(FLORICULTURE AND LANDSCAPE ARCHITECTURE)

by

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2019

CERTIFICATE- I

This is to certify that the thesis entitled **"Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching"**submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE (Floriculture and Landscape Architecture)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya Gwalior (M.P.) is a record of the bona-fide research work carried out by **Mr. Jayant Patel** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and Director of Instruction.

No part the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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(Chairman of the Advisory Committee)

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Member	(Dr. R. Gallani)	…….....
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CERTIFICATE- II

This is to certify that the thesis entitled **"Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching"**submitted by **Mr. Jayant Patel to** the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture)** in **Horticulture** in the **Department of Floriculture and Landscape Architecture,** has been, after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

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Acknowledgments

First of all I express my deep sense of adoration towards the Omniscient and Almighty God for giving me the opportunity of doing Master of Science (Agriculture) in Horticulture in the Department of Floriculture and Landscape Architecture.

I express my profound sense of gratitude and indebtedness from the core of my heart towards my most respected guide and chairman of my advisory committee Dr. Anuj Kumar Assistant Professorand Co-Chairman Dr. (Smt). Vidhya Sankar.M. Scientist Deptt. of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, (Mandsaur), R.V.S.K.V.V. Gwalior for their praiseworthy guidance, valuable suggestions, overwhelming help, inspiration and encouragement during the course of investigation without which it would have not been possible to accomplish this stupendous task.

I owe a whole hearted gratitude to all venerable members of my Advisory Committee, Dr. R. Gallani Assistant Professor Department of Soil Sciences and Agricultural Chemistry, Dr. G.P.S. Rathore, Principal scientist, Department of Statistics and Computer Science, K.N.K. College of Horticulture, Mandsaur for their for their relevant guidance, inspiring suggestions, ever available generous help during the tenure of work.

With profound respect I am extremely thankful to Professor Dr. S.K. Rao, Hon'ble Vice Chancellor, R.V.S.K.V.V. Gwalior, Dr. A. K. Singh, Director of Instruction and, Dr. Mridula Billore, Dean Faculty of Agriculture, R.V.S.K.V.V. Gwalior, (MP). With deepest sense of humility and gratefulness, I feel myself duly bound to express my heartfelt and sincere thanks to Dr. S. N. Mishra, Dean K.N.K. College of Horticulture, Mandsaur (M. P.).Special thanks toDr. S. S. Kushwah, Asst. Professor,Dr. K.C. Meena, Asst. Professor, Mr. B.K. Patidar, Asst. Professor, Dr. G.S. Chundawat, Asst. Professor, Dr. Ajay Haldar, for their immense help in each and every step of research work.

Words cannot express the heartfelt gratitude for my most revered My Parents Shri. Hanuman Patel, Smt. Anita Patel, nana ji Shri. Asharam Patel nani ji Smt. Rambati Patel and relatives who gave me sincere affection, everlasting love, blessings, support and encouragement throughout my educational career.

I would also like to express my gratitude for the co-operation and encouragement of my beloved seniors Mr. J. Bhandhari sir, D.P. Patel sir, Sachin Patidar sir, Salini mam, swati mam, Payal mam, Hemant sir, Jitendra sir who have directly or indirectly co-operated with me during the tenure of work.

Express my sincere thanks to my batch mates and all of my friends, especially, Shubham Khatri, Birendr Pandey, Reena Parmar, Manohar G.V., Surendra Ghosi, Shakti Prasad, Brajbhusan varma and juniors Gopal, Bindesh, Indrani, Prashant, Vidhyanand, Sumit, Ojesh, Arvind, Puspa, Sanat, Prerna, Siddhi and my room partner Sonal Tiwari for rendering their constant support, co-operation and valuable help throughout the course of investigation.

I also place on record, my sense of gratitude to one and all who, directly or indirectly have lent their helping hands in this venture.

Place: Mandsaur
Date: …/…/……

Jayant Patel

Contents

LIST OF TABLE

List of Figures

List of Plates

List of Appendices

List of Abbreviations used in text

%	:	Percentage
&	:	And
/	:	Per
@	:	At the rate of
^{o}C	:	Degree Celsius
ANOVA	:	Analysis of Variance
C.D.	:	Critical Difference
cm	:	Centimeter
cv	:	Cultivar
d.f.	:	Degree of Freedom
DAP	:	Days After Planting
DAT.	:	Days After Transplanting
EC	:	Emulsifiable Concentrate
et al.	:	et-alai
Fig.	:	Figure
g	:	Gram (s)
ha	:	Hectare
i.e.	:	That is
Kg	:	Kilogram (s)
m	:	Meter
M. S. S.	:	Mean Sum of Square
m^2	:	Meter square
Max.	:	Maximum
Mg	:	Milli Gram
MH	:	Million Hectare
Min.	:	Minimum
ml	:	Milliliter
Mm	:	Millimeter
MT	:	Million Tonne
No.	:	Number
NS	:	Non Significant
MOP	:	Murat of potash
K	:	Potassium
N	:	Nitrogen
P	:	Phosphorus
q/ha	:	Quintal per Hectare
Qt	:	Quintal
RH	:	Relative Humidity
RVSKVV	:	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
S.Em	:	Standard error of mean
Sig.	:	Significant
Viz.	:	(Videlicet) Namely

CHAPTER- I

INTRODUCTION

Flowers are the symbols of prosperity, love, beauty and peace. Flowers are associated with human being from birth to till death. Flowers not only beautify our surroundings but also improve the quality of life. The flowering trees checks the pollution and develops a sustainable ecosystem (Syamal, 2014).

It is not possible to define 'Floriculture' in the sense as one can define a triangle in the language of geometry. But possibly the closest definition is, "Floriculture is the art and knowledge of growing flowers to perfection." But this definition is also not complete as floriculture includes not only flowers but also many ornamental foliage plants, cacti and other (Randhawa, 1985).

The scope of floriculture in India has tremendously increased, which is evident from the government starts, budgetary support and increase in area, production, consumption and export of floricultural products (Salaria, 2011).

During the 8^{th} 5-year plan, the government of India, considering floriculture as an extreme focus segment. The domestic industry is growing at annual rate of 7-10% per annum (Singh, 2006).

Among the flower crops because of its merits and favorable agro climatic conditions of the state, marigold occupied a prominent place. It has been observed that demand for these flowers has been shown a steady increase during recent year (Mohanty *et al.*2015).

Marigold (*Tagetes erecta* L.) a member of family Asteraceae. It is mainly cultivated for ornamental purpose all over the world. It is a native of central and South America, especially Mexico. The name of *Tagetes* was given after Tages a demigod, known for his beauty. In India, marigold was introduced by Portuguese and it became popular and spread quickly because of its easy cultivation, adaptability to varying soils and climatic conditions(Singh, 2006).

There are about 33 species of the genus *Tagetes.* The two commercially important spp. are *T. erecta* L. commonly called African

marigold and *T. patula* popular as French marigold. Plants of *T. erecta* are hardy annual, tall about 90 cm, erect and branched. Leaves are pinnately divided and leaflets are lanceolate and serrated. Flowers are single to fully double and large sized of globular heads. The florets are either 2 lipped or quelled. Flowers colour varies from lemon yellow to yellow, golden yellow or orange(Koure*t al*. 2012).

It is suitable for pigment extraction, meal production, natural colorant preparation, oil extraction etc., which can help the farmers for maximizing their farm income. Now-a-days many industries are interested in marigold cultivation owing to its potential in value addition.Marigold has been found to be highly effective in keeping the population of nematode under control(Baskaran and Abirami 2017).

Marigold is one of the most important flower crops grown commercially in different parts of India such as Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Haryana, West Bengal, Maharashtra, Chattisgarh, Tamil Nadu and Sikkim etc.Madhya Pradesh is having many natural advantages like abundant sunlight, suitable temperature for good growth of marigold in different seasons and its location. In Madhya Pradesh (Ratlam, Chhindwara, Indore, Dhar, Ujjain, Mandsaur etc.) are major producing districts of marigold (NHB, 2017).The estimated area under marigold in India was 64650 ha with a production of 608970 metric tonnes of loose flower and 7900 metric tonnes of cut flower during the year 2016-2017 as well as in Madhya Pradesh estimated area 5710 ha with a production of 138910 metric tonnes of loose flower in the year 2015-2016(IndiaAgristat, 2019). There is a huge demand of flowers in the season of festivals like Dushehra and Diwali as well as during marriages.

A large number of prominent cultivars are available in African marigold which grown in different part of the country and one of them cv. Pusa Narangi Gainda is having potential for year round flower production (Singh *et al.*2015).

So far as commercial cultivation of marigold is concerned, the climatic factors are beyond the control of human beings but growth, flowering and flower production of marigold can be improved to a large extent by the judicious use of fertilizers, appropriate planting distance, cultural operations

and pinching etc. (Koure*t al*. 2012). In wide planting the individual plant may get sufficient distance for its growth and development. Due to wide spacing per unit production is less on the other hand; in closer spacing the plants do not get sufficient distance for their development and consequently drastic reduction occurs at close planting. Hence, planting distance should be regarded for massing sufficient production of flowers with good quality in African marigold (Singh *et al*. 2018).

Pinching operation might be due to the fact that by removal of apical portion move energy might have been to promote the number of side branches. Number of side branches directly positive correlated the yield of flowers in African marigold (Singh *et al*. 2018).

Although, marigold is grown by a large number of farmers in Madhya Pradesh, but there is very less information available regarding its actual package of practices to achieve higher as well as quality flower production. Thus, keeping in view the above facts an experiment entitled **"Response of African marigold (*Tagetes erecta* L.) cv. PusaNarangiGainda to spacing and pinching"**is carried out with the following objectives:-

1. To study the effect of spacing on the growth, flowering and seed yield of African marigold.
2. To study the effect of pinching level on the growth, flowering and seed yield of African marigold.
3. Find out the best combination of spacing and pinching levels on growth, flowering and seed yield of African marigold.

CHAPTER - II

REVIEW OF LITERATURE

In India marigold is one of the most important and commonly grown flower. Marigold gained popularity amongst gardeners and flowers growers on account of its easy culture and wide adaptability. Its habit of free flowering, short duration to produce marketable flowers, wide spectrum of attractive color, shape, size and good keeping quality attracted the attention of flower growers and flower auctioneers. Its successful cultivation depends a lot on proper spacing and pinching. Pinching is invariably the limiting factor for marigold crop. It improves the vegetative growth and increases the number of flowers as well as flower yield. A brief review of research work done on these aspects is being discussed in the following chapter. It includes brief results of the research work done in India and abroad which is similar to or closely related with the present investigation.

2.1 Growth parameters

Ravindran *et al.*(1986) conducted an experimentto see the effects of spacing and nitrogen levels on growth, flowering and yield of African marigold (*Tagetes erecta* L.). Plants grown at 30x30, 45x30 or 60x30 cm received N at 0-90 kg/ha plus PK and FYM as basal dressing.Theyobserved that more number of secondary branches and plant spread occurredunder wider spacing (60x60 cm).

Bhati and Chitkara (1987) carried out an experimentto see the effects of spacing at 40 x 40, 40 x 50 or 50 x 50 cm and pinching at 15 and 30 days after transplanting on the cultivars African Giant Orange, African Giant Yellow and French Dwarf Red. Plants of all cultivars were taller under close spacing whereas, pinching reduced plant height but increased spread. These effects were most marked when pinching was done at 30 days after transplanting.

Chanda and Roychodhury (1991) conducted an experimentto see the effect of time of planting and spacing on growth, flowering and yield of African marigold (*Tagetes erecta* L., cv. Siracole).They found that plant height, plant

spread and number of primary branches, were higher at the wider spacing (40 x 40 cm).

Mohanty *et al*.(1997) conducted an experimentto see the effects of planting time and spacing on rooted cuttings of *T. erecta.*They observed that May and July planting gave the greatest number of branches per plant, plant height and stem thicknessincreased significantly as plant spacing increased.

Srivastava *et al.* (2002) studiedthe effect of spacing and pinching on growth, flowering and yield of marigold (cv. Pusa Narangi Gainda). Treatments comprised: 3 spacings 40x40, 40x50 and 40x60 cm (S_1, S_2 and S_3, respectively) and 4 pinching treatments (no pinching, pinching at 20, 30 and 40 days after transplanting (P_0, P_1, P_2 and P_3, respectively). Result showed that plant height was maximum under S_1(40x40 cm).

Sehrawat *et al.* (2003) conducted an experimentto see the effects of N rates (0, 10, 20, 30 and 50 g/m^2 through urea) and pinching (at 30, 40 or 50 days after transplanting or DAP) on the performance of *T. erecta*.They observed that plant height was checked with pinching treatments compared to control and pinching at 30 days after transplanting gave the minimum plant height.

Koure*t al*. (2012) conducted an experiment to see the response of different spacing and pinching level on African marigold cv. Pusa Narangi Gainda and observed that increase in number of secondary branches were recorded under delayed pinching (40 DAT) treatment.

Kumar *et al.* (2012) conducted an experimentto seethe effect of planting distance andpinching on growth and flowering behaviour of Africanmarigold (*Tagetes erecta* Linn) cv. ‘Pusa Narangi’. Sixtreatment combinations comprising of two spacing (50 cmx 40 cm and 50 cm x 50 cm) and three pinching (30, 40 and50 days after planting) were assigned in factorialrandomized block design with four replications. Maximumplant height and secondary branches per plant increased atcloser spacing of 50 cm x 40 cm; however, spread and diameter of plant, primary branchesper plant increases inwider spacing (50 cm x 50 cm). Laterpinching has reduced plant

height and plant spread. Interaction between spacing and pinchingwere significant for number of secondary branches plant^{-1}.

A field experiment was conducted during the winter season in 2005-2006. Therewere total twenty-four treatments, *viz* three cultivars (LocalOrange, Pusa Basanti and Pusa Narangi), two spacing(60 X 60 cm and 45 X 60 cm) and four GA_3 concentrations(0, 100, 200 and 300 ppm), and each were replicated thricein Factorial Randomized Block Design. All the charactersexceptplant height at both flower initiation and full bloom stages were significantlyinfluenced by spacing. The plant spread at both flower initiation and full bloom stages, number of branches per plant were significantlyhigher in wider spacing (S_1) as compared to closer spacing(S_2). All the vegetative growthcharacters were greatly influenced by GA_3 at 300 ppm. Ithad recorded maximum plant height at first flower initiation and full bloom; plant spread at flower initiation and full bloom stage. The maximum number of branches per plant was observed with200 ppm GA_3**(Deshmukh*et al.*2014).**

Rajyalakshmi and Rajasekhar (2014) carried out an experimentto see the response of different growth regulators (NAA, GA, Cycocel and Ethrel) and pinching on growth & flowering of African marigold *(Tagetes erecta* L.) cv. Pusa Narangi Gainda in different dates of planting.The highest plant heightwas observed with GA 300ppm spray in all the three dates of planting in August, September and October. The highestreduction in plant height was observed with 500 ppmCycocel spray (respectively in August, September and October datesof planting) followed by ethrel spray at 500ppm in all thethree dates of planting.Significant increase in number of side shootswas recorded due to application of growth retardantcycocel@500ppm (respectively in August, September and October datesof planting).

Lakshmi *et al*. (2014)conducted an investigation to study the effect of different planting dates and spacing on growth andyield of African marigold cv. 'Pusa Narangi Gainda'. The treatments comprised of four planting dates, *viz*., 1st September(D_1), 1st October (D_2), 1st November (D_3) and 1st December (D_4) and three plant spacings, *viz.,* 40×20 cm (S_1),40×40 cm (S_2) and 40×60 cm (S_3). Number of primary branches per plant and plant spread were found to be statistically higher in 1st Octoberplanting. Other growth parameters like number of primary branches per plant and plant spread was found to be

significantly higher in 40×60 cm.Further, the interaction effect of planting dates and spacing on plant height, plant spread and number of primary branches per plant was found to be significant.

Yadav *et al.* (2004) conducted an experimentto see the effects of spacing and N rate on the performance of *T. erecta*. The greatest stem diameter, plant spread, and number of leaves, number of primary and secondary branches were obtained under 60x45 cm spacing, while maximum plant height was recorded under 40x30 cm spacing.

Meena*et al*. (2015) conducted an experiment to see the response of planting time, spacing and pinching on plant growth and seed yield characters in African marigold**.** The maximum plant height was recorded in September planting, 30 cm × 30 cm spacing and in without pinching treatments. The number of branch/plant and diameter of main stem were higher in October planting, 30 cm × 60 cm spacing but pinching at 30 DAT had produced maximum diameter of stem than others.

Prakash*et al.* (2016) carried out an experiment to see the effect of season and pinching on different varieties of African marigold. Dataindicating that pinching had significant positive effect on growth of African marigold. Among the different season, monsoon (S_2) season showed the better results with respect of plant height.

Baskaran and Abirami(2017) conducted an experiment to study the effect of pinching on flower yield of African marigold cv. Pusa Narangi Gainda. The experiment consisted of three treatments T_1 (Control) - no pinching, T_2-single pinching 20 days after transplanting and T_3-double pinching 15 days after single pinching. Data indicate that among the all different treatments, T_3 (double pinching) showed the best results with respect of maximum plant spread and number of branches.

Anuradha*et al.* (2017) conducted an experiment to see the response of “Effect of pinching and plant growth regulators on growth, flowering, yield and quality of African marigold (*Tagetes erecta* L.) cv. Calcutta Orange”. Data indicate that pinched plants showed the better results compared to unpinched plants with respect of vegetative parameters. Among the growth regulators,

GA_3 spray recorded significantly higher plant height, stem girth and plant spread.

Singh *et al.* (2017) conducted an experiment to see the response ofpinching and nitrogen on growth and flowering in marigold cv. Pusa Narangi Gainda. Among the treatment, no pinching at 3% N recorded maximum plant height. The number of secondary branches per plant was maximum in double pinching + 2% N. The number of leaves recorded maximum in double pinching + 1% N.

Nain *et al.* (2017) carried out an experiment to see theoptimize pinching time and spacing in African marigold for achieving better growth, flowering and yield. They find that maximum number of branches/plant and plant spread were recorded with pinching at 28 DAT, whereas, maximum plant height was obtained in un-pinched plants. In case of spacing, maximum plant spread and primary branches/plant was recorded at 40 x 40 cm, whereas, maximum plant height was observed with 30 x 30 cm. Results revealed that plants pinched at 28 DAT with widest spacing (40 x 40 cm) were found best for better growth of African marigold.

Sarkar *et al.* (2018) carried outan experiment to see the effect of GA_3 and pinching on growth and flowring of African marigold. The result indicated that the important growth and physiological characters were significantly influenced by gibberellic acid and pinching treatments. The application of GA_3 at 200 ppm recorded significantly higher plant height, number of branches/plant, total leaf number. Among the pinching treatments, pinching at 40 DAT recorded significantly maximum number of branches, total leaf number; whereas maximum plant height was found under no pinching.

Khan *et al.* (2018) conducted an experiment to see the effect of pinching on growth and flower production of marigold. Analysis of data revealed that pinching had a significant effect on most of the attributes of marigold. Regarding pinching a maximum number of branches, plant height and stem diameter was observed in pinched plants.

2.2 Flowering parameters

Ravindran *et al.* (1986) conducted an experiment to see the effects of spacing and nitrogen levels on growth, flowering and yield of African marigold (*Tagetes erecta* L.). Plants grown at 30x30, 45x30 or 60x30 cm received N at 0-90 kg/ha plus PK and FYM as basal dressing.They observed that significantly more number of flowersper plot were obtained with closer spacing of 30x30 cm.

Mohanty *et al*.(1997)carried out an experimentto see the effects of planting time and spacing on rooted cuttings of *T. erecta* were planted on 1 May, 1 July, 1 September, 1 November or 1 January at 4 plant spacing's (30 x 20, 40 x 20, 30 x 30 and 40 x 30 cm) andobserved that fresh weight per flowerincreased significantly as plant spacing increased.

Sehrawat *et al.* (2003)conducted an experimentto see the effects of N rates (0, 10, 20, 30 and 50 g/m2 through urea) and pinching (at 30, 40 or 50 days after transplanting or DAP) on the performance of *T. erecta* cv. African Giant Double Orange. They found that pinching at 30 days after transplanting resulted in maximum number of flowers and flower yield. Number of days to first flower bud initiation, 50 per cent flowering and duration of flowering increased significantly by pinching treatments.

Kumar *et al.* (2012) reportedthe effect of planting distance and pinching on African marigold.They found that opening of first flower was delayed in closer spacing (50 cm x40 cm), whereas duration of flowering increased with wider spacing (50 cm x 50 cm). Interaction between spacing and pinching were significant for duration of flowering.

Koure*t al*. (2012) conducted an experiment to evaluate the response of different spacing and pinching level on African marigold cv. Pusa Narangi Gainda and observed that wider spacing (40 x 60) and delayed pinching (40 DAT) increased the size and quality of flowers. However, the increase in duration of flowering were recorded under delayed pinching (40 DAT) treatment.

A field experiment was conducted to measure the effect of different time of pinching with different levels of growth retardants on flowering behavior and yield of African marigold. Comprising of three levels of pinching i.e. un-pinched, pinching at 20 DAT and pinching at 30 DAT and five levels of growth retardants using, control, Cycocel 500 ppm, Cycocel 1 000 ppm, Alar 1 500 ppm and Alar 3000 ppm, during winter season of 2007-2008 and 2008-2009. Among the pinching 20 DAT with Cycocel 1000 ppm was the best for improving floral parameters of African marigold. **(Pushkar *et al*. 2012).**

A field experiment was conducted during the winter season in 2005-2006. There were total twenty-four treatments, *viz* three cultivars (Local Orange, Pusa Basanti and Pusa Narangi), two spacing (60 X 60 cm and 45 X 60 cm) and four GA_3 concentrations (0, 100, 200 and 300 ppm) and each were replicated thrice in Factorial Randomized Block Design. All the characters except duration of flowering were significantly influenced by spacing. **(Deshmukh *et al.,* 2014).**

Rajyalakshmi and Rajasekhar (2014). The experiment was carried out to see the response of different growth regulators (NAA, GA, Cycocel and Ethrel) and pinching on growth & flowering of african marigold *(Tagetes erecta* L.) cv. Pusa Narangi Gainda in different plantingdates.The maximum number of flowers per plant was recorded with the application of 500 ppm Cycocel flowers in August, September & October dates of planting respectively.

Lakshmi *et al*. (2014) carried out an experiment to study the effect of different planting dates and spacing on growth and yield of African marigold cv. 'Pusa Narangi Gainda'. The treatments comprised of four planting dates, *viz*., 1st September (D_1), 1st October (D_2), 1st November (D_3) and 1st December (D_4) and three plant spacing's, *viz.,* 40×20 cm (S_1), 40×40 cm (S_2) and 40×60 cm (S_3). Growth parameters like flower diameter was found to be significantly

higher in 40×60 cm. However, duration of flowering was found to be significantly higher in 40×40 cm spacing which, in turn, was statistically at par with 40×60 cm spacing. Further, the interaction effect of planting dates and spacing on flower diameter and weight of flower per plant was found to be significant.

Pushkar and Singh (2015) conducted an experiment to see the response of different time of pinching with different levels of growth retardants on flowering behaviour and yield of African marigold and observed that the pinching 20 DAT with Cycocel 1000 ppm was the best for improving floral parameters of African marigold. Early pinching (20DAT) with higher concentration of Cycocel (1000ppm) was suggesting for fresh weight of flowers.

Meena*et al*. (2015) conducted an experiment to see the response of planting time, spacing and pinching on plant growth and seed yield characters in African marigold**.** It was noted that planting time, wider spacing and pinching at 60 DAT had significant effect on number of days to first flowering.

Singh *et al.* (2015) carried out an experiment to see the performance of marigold (var. Pusa Narangi Gainda) to spacing's and planting dates at bimonthly interval *i.e.* on first day of March, May, July, September, November and January. In both the years wider spacing of 40 cm × 40 cm produced best results with respect to maximum flower diameter and weight of individual flower.

Prakash*et al*. (2016) carried out an experiment to see the effect of season and pinching on different varieties of African marigold. Dataindicating that pinching had significant positive effect on flowering of African marigold.

Baskaran and Abirami(2017) conducted an experiment to study the effect of pinching on flower yield of African marigold cv. Pusa Narangi Gainda. The experiment consisted of three treatments T_1 (Control) - no pinching, T_2-single pinching 20 days after transplanting and T_3-double pinching 15 days after single pinching. Data indicate that among the all different treatments, T_3 (double pinching) showed the best results with respect of duration of flowering, size of flower and weight of single flower.

Nain *et al.* (2017)reported the effect of pinching and spacing in African marigold for achieving better growth, flowering and yield. They found that duration of flowering were significantly recorded in plants pinched at 28 DAT at 5% level of significance, whereas, flower diameter, fresh weight of flower was obtained in un-pinched plants. In case of spacing, duration of flowering, flower diameter, fresh weight of flower was recorded at 40 x 40 cm. Results revealed that plants pinched at 28 DAT with widest spacing (40 x 40 cm) were found best for flowering of African marigold.

Singh *et al.* (2017) conducted an experiment to see the response of pinching and nitrogen on growth and flowering in marigold cv. Pusa Narangi Gainda. The treatments include three levels of pinching i.e. no pinching, single pinching at 40 days after transplanting and double pinching at 40 and 60 days after transplanting with four levels of nitrogen i.e. 0%, 1%, 2% and 3%. Among the treatment, no pinching at 3% N recorded maximum fresh weight of flower, dry weight of flower, flower diameter. Treatment with no pinching without N recorded earliest days to bud initiation and maximum duration of flowering.

Anuradha*et al*. (2017)studied the response of “effect of pinching and plant growth regulators on growth, flowering, yield and quality of African marigold (*Tagetes erecta* L.) cv. Calcutta Orange”. Data indicate that pinched plants showed the better results compared to unpinched plants with respect of flowering parameters. Among the growth regulators, GA_3 spray recorded significantly flowering. The interactions between pinching and growth regulators among the treatments did not exhibit significant results for all flower quality parameters. The experiment can be concluded that pinching of apical bud and foliar spray of GA3 at 200 ppm independently gave better quality flowers with maximum benefit in African marigold cv. Calcutta Orange.

Khan *et al*. (2018)carried out an experiment to see the effect of pinching on growth and flower production of marigold. Analysis of data revealed that pinching had a significant effect on most of the attributes of marigold.

Singh *et al*.(2018) observe the influence of spacing and pinching on growth and flowering in African marigold. It can be concluded that wider spacing showed significantly better effect on flower quality and quantity parameters i.e. flower diameter and flower weight. Although, flowering parameters i.e. flower diameter and flower weight were not significantly affected by spacing and pinching combinations.

2.3 Post harvest quality and biochemical analysis parameters

Singh and Arora (1980) conducted an experiment to see the effect of spacing and pinching on African marigold(*Tagetes erecta*L.). They found that widest spacing with 40 DAT gave the best results with respect of flower yield.

Gowda and Jayanthi (1986)conducted an experimentto see the effects of spacing and season of planting on growth and yield of marigold (*Tagetes erecta* Linn). Data indicate that 20 x50 cm spacing in September gave the highest flower yield.

Ravindran *et al.* (1986) conducted an experiment to see the effects of spacing and nitrogen levels on growth, flowering and yield of African marigold (*Tagetes erecta L*.). Plants grown at 30x30, 45x30 and 60x30 cm received N at 0-90 kg/ha plus PK and FYM as basal dressing. Theyreported that the highest floweryield of marigold was obtained with a spacing of 30x30 cm.

Chanda and Roychodhury (1991) conducted an experiment to see the effects of, *T. erecta* Siracole cuttings were planted at monthly intervals from 15 July to 15 June 1989 at 2 different spacings (30 x 30 cm or 40 x 40 cm). Result showed that wider spacing gave the best results with respect of flower yield/plant.

Mohanty *et al*.(1997)conducted an experimentto see the effects of planting time and spacing on rooted cuttings of African marigold. They observed that thehighest flower yield per plant was achieved at a spacing of 40 x 30 cm.

Koure*t al*. (2012)studied the response of different spacing and pinching level on African marigold cv. Pusa Narangi Gainda and observed that close spacing (40 x 40 cm) with delayed pinching (40 DAT) showed the best results with respect of flower yield.

A field experiment was conducted to measure the effect of different time of pinching with different levels of growthretardants on flowering behavior and yield of African marigold. Comprising of three levels of pinching i.e. un-pinched, pinching at20 DAT and pinching at 30 DAT and five levels of growth retardants using, control, Cycocel 500 ppm, Cycocel 1000 ppm, Alar1 500 ppm and Alar 3000 ppm, during winter season of 2007-2008 and 2008-2009. Among the pinching 20 DAT with Cycocel 1000 ppm was the best for improving floral and yield parameters of African marigold. Early pinching (20DAT) with higher concentration of Cycocel (1000 ppm) was suggesting for maximum yield of flowers per hectare. **(Pushkar *et al.* 2012).**

Kumar *et al.* (2012) conducted an experimentto seethe effect of planting distance andpinching on growth and flowering behaviour of Africanmarigold (*Tagetes erecta* Linn) cv. 'Pusa Narangi'.They found that flower yield was increased with wider spacing and reduce with later pinching. However Interaction between spacing and pinchingwere significant for flower yield. The maximum marigold flower yield was reported at closer spacing of 50 cm x 40 cm along withpinching at 40 DAP.

A field experiment was conducted during the winter season in 2005-2006. Therewere total twenty-four treatments, *viz* three cultivars (LocalOrange, Pusa Basanti Gainda and Pusa Narangi Gainda), two spacing(60 X 60 cm and 45 X 60 cm) and four GA_3 concentrations(0, 100, 200 and 300 ppm), and each were replicated thricein Factorial Randomized Block Design. The flower yield was significantly higherunder closer spacing (S_2).**(Deshmukh*et al.,*2014).**

Rajyalakshmi andRajasekhar (2014)carried out an experiment to see the response of different growth regulators (NAA, GA, Cycocel and Ethrel) and pinching on growth & flowering of african marigold *(Tagetes erecta* L.) cv. Pusa Narangi Gainda in different dates of planting. The result raveled that maximum flower yieldrecorded with cycocel 500ppm.

Lakshmi *et al*. (2014)studied the effect of different planting dates and spacing on growth andyield of African marigold cv. 'Pusa Narangi Gainda'. The treatments comprised of four planting dates, *viz*., 1st September(D_1), 1st October (D_2), 1st November (D_3) and 1st December (D_4) and three plant spacing's, *viz.,* 40×20 cm (S_1),40×40 cm (S_2) and 40×60 cm (S_3). Among various spacing's, 40×20 cm recorded significantly maximum flower yield per hectare than 40×40 cm and 40×60 cm spacing. Further, the interaction effect of planting dates and spacing onflower yield per hectare was found to be significant.

Yadav *et al*. (2004) conducted an experimentto see the effects of spacing and N rate on the performance of *T. erecta*. The greatest flower yields per plant were obtained under 60x45 cm spacing.

Singh *et al.* (2015)conducted an experiment to see the performance of marigold (var. Pusa Narangi Gainda) planted at threespacing's and on six different dates at bimonthly interval *i.e.* on first day of March, May, July, September, November and January.The crop planted on 1st March showed early flowering compared to other planting dates. The maximum flower yield was recorded September planted showed the maximum flower yield at 40cm × 20 cm spacing.

Pushkar and Singh (2015) conducted an experiment to see the response ofdifferent time of pinching with different levels of growth retardants on flowering behaviourand yield of African marigold. Comprising of three levels of pinching i.e. un-pinched, pinching at 20 DAT and pinching at 30 DAT and five levels of growthretardants using, control, Cycocel 500ppm, Cycocel 1000ppm, Alar 1500ppm and Alar3000ppm. Among thepinching 20 DAT with Cycocel 1000ppm was the best for improving yield parameters of African marigold. Early pinching (20DAT) with higherconcentration of Cycocel (1000ppm) gave the best results with respect of maximum yield of flowers per plant.

Prakash*et al*. (2016) carried out an experiment to see the effect of season and pinching on different varieties of African marigold. Dataindicating that pinching had significant positive effect on yield of African marigold.

Nain *et al*. (2017) conducted an experiment to see the optimize pinching time and spacing in African marigold for achieving better growth, flowering and yield. Experiment comprises of two levels of pinching (no pinching & pinching at 28 DAT i.e. Days After Transplanting) and three levels of spacing (40 x 40 cm, 40 x 30 cm & 30 x 30 cm) in all possible combinations. Results revealed that plants pinched at 28 DAT with widest spacing (40 x 40 cm) were found best for yield of African marigold.

Anuradha*et al.*(2017) conducted an experiment to see the response of "Effect of pinching and plant growth regulators on growth, flowering, yield and quality of African marigold (*Tagetes erecta* L.) cv. Calcutta Orange". They found that pinching gave the best results with respect of flower yield.

Singh *et al.* (2017) carried out an experiment to see the response ofpinching and nitrogen on growth and flowering in marigold cv. Pusa Narangi Gainda. The treatments include three levels of pinching *i.e*. no pinching, single pinching at 40 days after transplanting and double pinching at 40 and 60 days after transplanting with four levels of nitrogen *i.e*. 0%, 1%, 2% and 3%. The flower yield per plant was maximum in double pinching + 2% N.

Khan *et al.* (2018) conducted an experiment to see the effect of pinching on growth and flower production of marigold. Analysis of data revealed that pinching had a significant effect on most of the attributes of marigold. It was concluded from the above results that marigold could be pinched at one feet height for significant flower production.

Singh *et al*. (2018) studied the effect of spacing and pinching on growth and flowering in African marigold. They found that maximum flower yield was obtained at the closer spacing.

Sarkar *et al.* (2018)carried out an experiment to see the response of gibberellic acid and pinching on growth and flowering of African marigold. The result showed that pinching at 40 DAT recorded maximum flower yield per hectare and maximum total chlorophyll content.

2.4 Seed yield parameters

Meena*et al*. (2015) conducted an experiment to see the response of planting time, spacing and pinching on plant growth and seed yield characters

in African marigold**.** The maximum seed yield/flower, seed yield/plant and seed yield/plot were recorded in September planting while closer spacing 30 cm × 30 cm had given higher seed yield/flower, seed yield/plant and seed yield/plot. The pinching at 60 DAT has given higher seed yield/ flower, seed yield/plant, seed yield/plot. Significant interaction between time of planting × spacing, pinching × spacing, time of planting × spacing × pinching were recorded for seed yield/flower and the interaction between pinching × time of planting was recorded significant for seed yield/plot.

A field experiment was conducted to see the effect of planting dates and pinching on seed production in African marigold cv. Sirakole. The experimentwascarried out during November, 2007 to June, 2008 with four planting dates and three levels of pinching. Shoot pinching at 30 days after planting was effective in bringing significant improvement in number and weightof seeds per head**(Mohanty *et al*., 2015).**

Baskaran and Abirami(2017) conducted an experiment to study the effect of pinching on flower yield of African marigold cv. Pusa Narangi Gainda. The experiment consisted of three treatments T_1 (Control) - no pinching, T_2-single pinching 20 days after transplanting and T_3-double pinching 15 days after single pinching. Data indicate that among the all different treatments, T_3 (double pinching) showed the best results with respect of maximum seed yield per plant.

CHAPTER – III

MATERIALS AND METHODS

The present investigation entitled**"Response of African marigold (*Tagetes erecta* L.) cv. PusaNarangiGainda to spacing and pinching "** was conducted during thekharifseason of 2018-19.The chapter deals with a concise description of materials and method adopted during the course of investigation are briefly described as follows:

Experimental Site

The experiment was conducted during Kharifseason of 2018-19 at Horticulture Research Farm, College of Horticulture, Mandsaur (MP), under RajmataVijayarajeScindiaKrishiVishwaVidyalaya, Gwalior (MP). The topography of the experimental field was uniform and plain with good irrigation facilities.

Climate of the region

Mandsaur belongs to sub-tropical climate having a mean temperature range of minimum 5°C and maximum 44°C in winter and summer, respectively. In this area most of the rainfall is received during early- July to mid- August with occasional shower in winter. Southwest monsoon is responsible for major part of annual precipitation. The average annual rainfall is 544.05 mm. Meteorological data recorded during the period of investigation are presented in Table 3.1 and are graphically shown in Fig.3.1.

Table 3.1: Weekly meteorological observations during the study period (July- 2018 to February -2019).

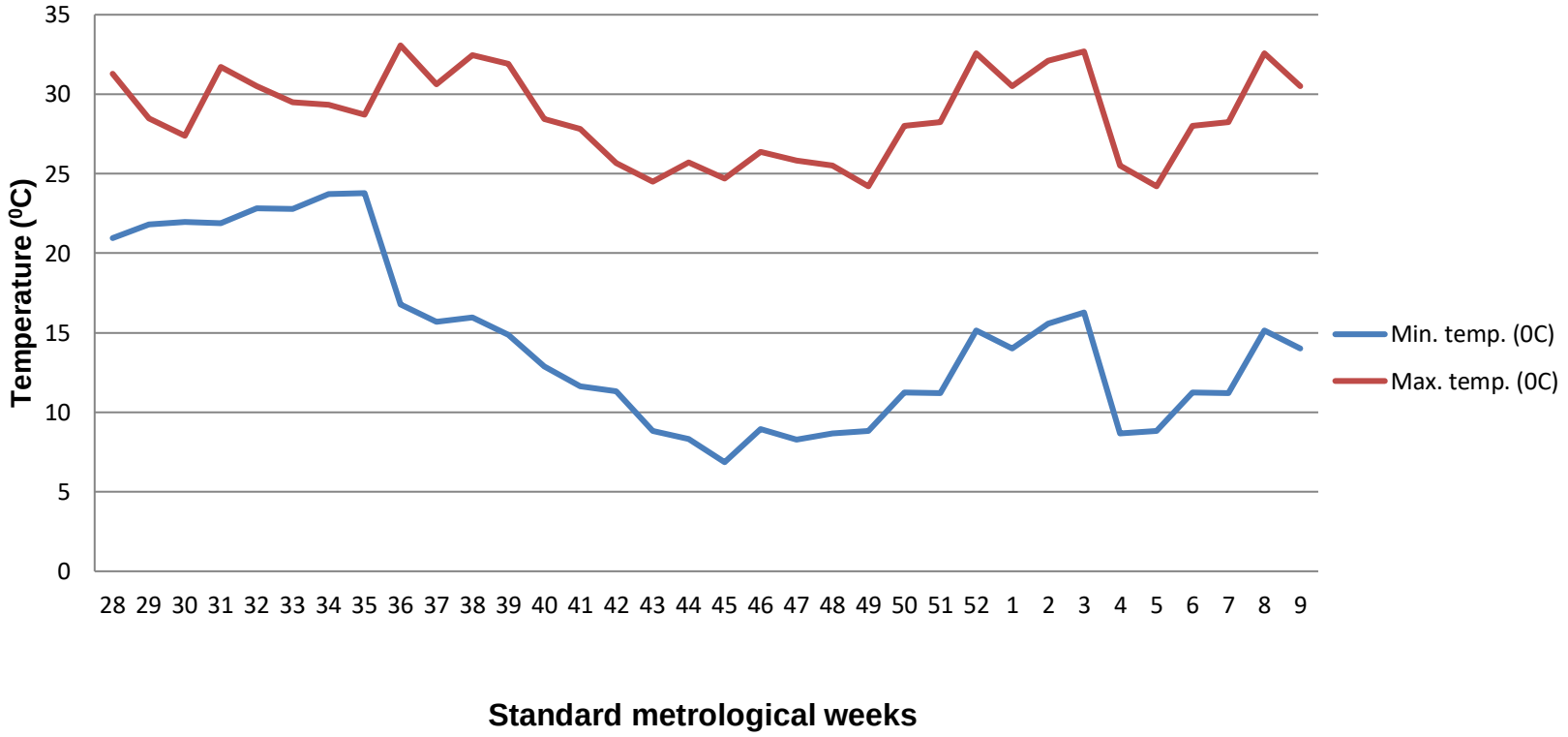
Stand. Week	Duration	Temperature		Relative Humidity (%)	Rainfall (mm)
		Min. (^oC)	Max. (^oC)		
28	09/07/18 to 15/07/18	20.94	31.28	78.71	182.1
29	16/07/18 to 22/07/18	21.81	28.48	90.57	33
30	23/07/18 to 29/07/18	21.95	27.40	77.71	21.4
31	30/07/18 to 05/08/18	21.90	31.70	91.14	0
32	06/08/18 to 12/08/18	22.84	30.52	72.85	59.50
33	13/08/18 to 19/08/18	22.78	29.50	94.85	95
34	20/08/18 to 26/08/18	23.74	29.35	90.57	133.50
35	27/08/18 to 02/09/18	23.78	28.73	91.00	45
36	03/09/18 to 09/09/18	16.80	33.07	46.29	52.2
37	10/09/18 to 16/09/18	15.67	30.63	58.57	0
38	17/09/18 to 23/09/18	15.96	32.47	56.00	0
39	24/09/18 to 30/09/18	14.86	31.90	60.57	122.05
40	01/10/18 to 07/10/18	12.90	28.43	68.14	0
41	08/10/18 to 14/10/18	11.63	27.81	76.71	0
42	15/10/18 to 21/10/18	11.34	25.69	68.00	0
43	22/10/18 to 28/10/18	8.81	24.50	71.43	0
44	29/10/18 to 04/11/18	8.31	25.71	66.14	0
45	05/11/18 to 11/11/18	6.86	24.69	69.29	0
46	12/11/18 to 18/11/18	8.93	26.37	74.14	0
47	19/11/18 to 25/11/18	8.29	25.84	69.00	0
48	26/11/18 to 02/12/18	8.67	25.51	68.57	0
49	03/12/18 to 09/12/18	8.83	24.21	65.29	0
50	10/12/18 to 16/12/18	11.26	28.01	70.71	0
51	17/12/18 to 23/12/18	11.19	28.26	64.29	0
52	24/12/18 to 31/12/18	15.14	32.57	51.86	0
1	01/01/19 to 07/01/19	14.01	30.49	57.43	0
2	08/01/19 to 14/01/19	15.57	32.10	55.29	0

3	15/01/19 to 21/01/19	16.29	32.71	52.14	0
4	22/01/19 to 28/01/19	8.67	25.51	68.57	0
5	29/01/19 to 04/02/19	8.83	24.21	65.29	0
6	05/02/19 to 11/02/19	11.26	28.01	70.71	0
7	12/02/19 to 18/02/19	11.19	28.26	64.29	0
8	19/02/19 to 25/02/19	15.14	32.57	51.86	0
9	26/02/19 to 04/03/19	14.01	30.49	57.43	0

Source: Meteorological observatory of the K.N.K. College of Horticulture, Mandsaur (M.P.)

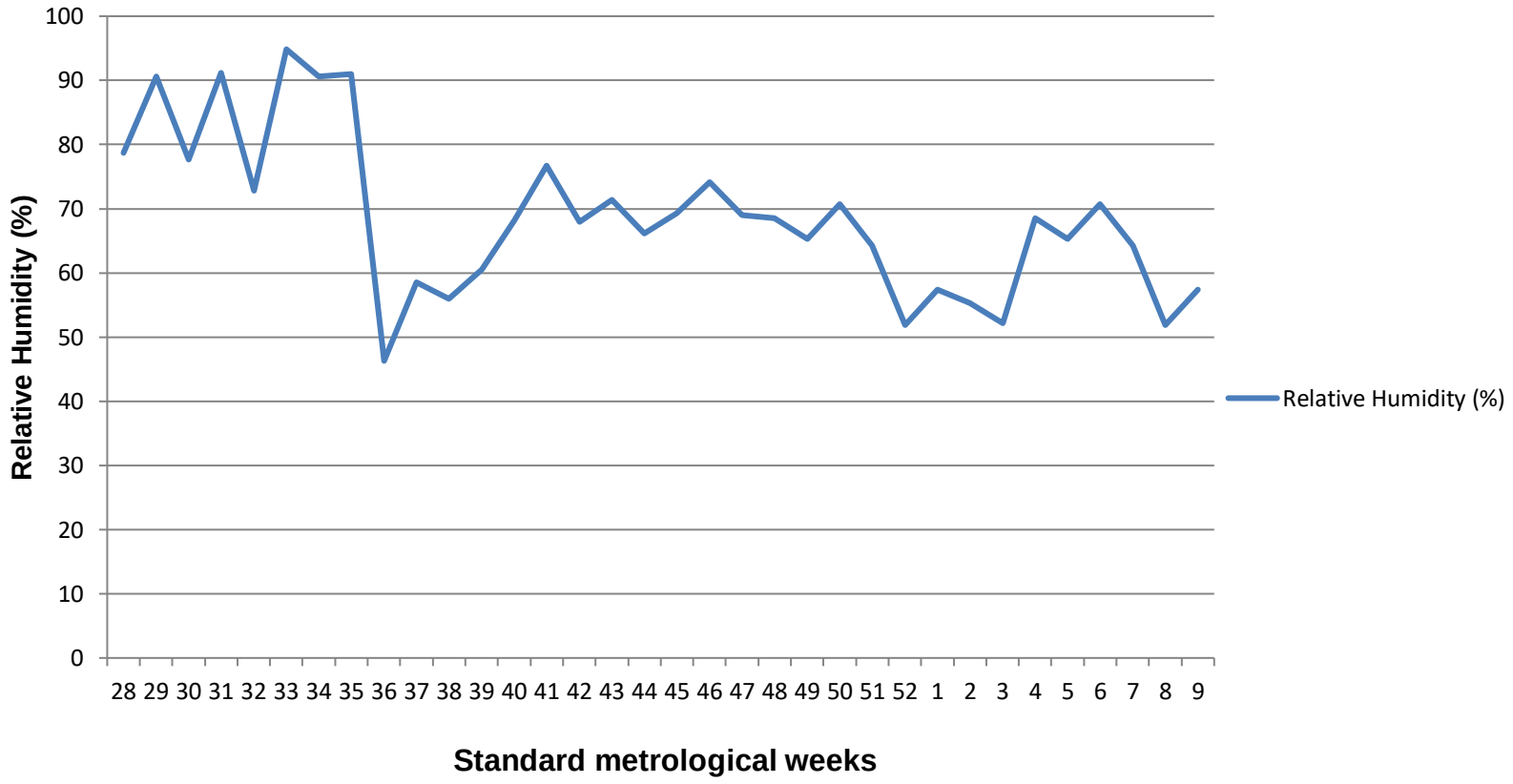
Temperature (^{0}C)

Fig. 3.1 Weekly metrological observations during the study period (July-2018 to February-2019) Temperature (^{0}C)



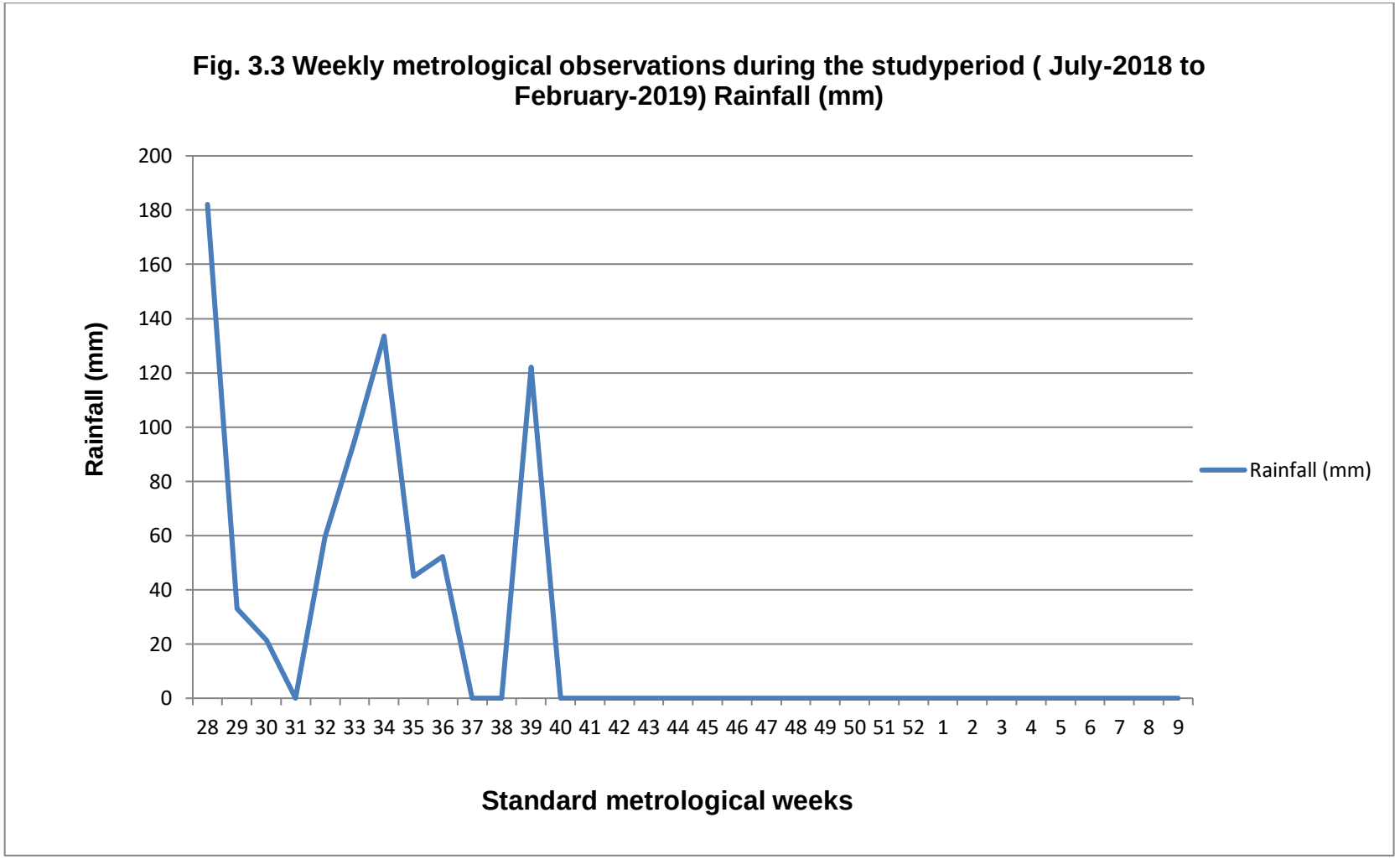
Relative Humidity (%)

Fig. 3.2 Weekly metrological observations during the study period (July-2018 to February-2019) Relative Humidity (%)



Rainfall (mm)

Fig. 3.3 Weekly metrological observations during the studyperiod (July-2018 to February-2019) Rainfall (mm)



Soil Characteristics of the Experimental Site

To ascertain physic-chemical characteristics of the soil during the year of study, soil samples from 0-15 cm depth were taken from different spots of the experimental field before application of fertilizer. A representative composite sample was prepared by processing and mixing them together and the sample was analyzed for physical and chemical properties.

Table 3.2: Physical and chemical composition of the soil sample of experimental site

S.No.	Particulars	Value obtained	Methods
	Physical Characters		
(a) (b) (c)	Sand % Silt% Clay%	35% 42% 28%	By International Pipette method (Piper, 1950)
	Chemical Characters		
(a)	Soil pH	8.36	Method No. 4, USDA Hand Book No.60(Richards, 1956)
(b)	Electric conductivity(dSm^{-1})	0.18	EC meter
(c)	Available nitrogen (kg ha^{-1})	195 (low)	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
(d)	Available phosphorus (kg ha^{-1})	7.6 (medium)	Olsen extraction method (Olsen *et al.* 1954)
(e)	Available potassium (kg ha^{-1})	145 (high)	Flame photometer method (Metson,1956)

Details of layout

The experiment was laid out inFactorial Randomized Block Design with two factors that isspacing and pinching.

Table 3.3:Experimental Details:

Particulars	Details
Name of crop	African marigold (*Tagetes erecta* L.)
Number of cultivars	1
Name of variety	Pusa Narangi Gainda
Experimental design	Factorial Randomized Block Design
No. of Treatments	9
No. of Replications	3
Total no. of Plots	27
Net Plot size	1.80 m x 1.80 m = 3.24 m^2
Net area of experiment	87.48 m^2
Gross area of experiment	149.48 m^2
Planting Distance	45 cm x 45 cm (row to row x plant to plant) 45 cm x 30 cm (row to row x plant to plant) 30 cm x 30 cm (row to row x plant to plant)
Distance between replication	1 m
Distance between plots	50 cm
No. of plants per plot	16,24,36
Total number of plants	684
No. of plants selected for study/ plot	5 for growth & flowering and 3 for seed
Date of sowing (Nursery)	09 July2018
Date of transplanting	09 August 2018

Treatment details: -

I. Different pinching level

1. P_0 - No pinching
2. P_1 - Single pinching (25 days after transplanting)
3. P_2 - Double pinching (15 days after single pinching)

II. Different spacing (cm)

1. S_1 - 45x45
2. S_2 - 45x30
3. S_3 - 30x30

Table 3.4: Treatment details

Symbol	Treatments
T_1	S_1P_0
T_2	S_1P_1
T_3	S_1P_2
T_4	S_2P_0
T_5	S_2P_1
T_6	S_2P_2
T_7	S_3P_0
T_8	S_3P_1
T_9	S_3P_2

Agronomical Operations

Nursery rising

The seedlings of African marigold were raised in nursery beds. The beds were dug and prepared thoroughly. The soil was well tilled and thoroughly pulverized. Stones, brick pieces, clods, weeds and such other undesirable material, if any were removed. The seeds were sown on 09th July 2018 after sowing; the seeds were covered with a fine mixture of soil and FYM.

First irrigation was given by means of water can immediately after sowing. Subsequently irrigations were done at regular intervals. Every possible care was taken to get healthy plants of uniform size.

Field preparation

The experimental area was ploughed twice with the help of tractor drawn implements in both directions and harrowing was done to break the clods and levelling was done.

Layout

The experimental area was finally levelled and divided into replications, channels, block borders and bunds. The plan of layout as shown in was executed on 5th August 2018.

Manure and Fertilizers

After executing the plan of layout, the calculated quantities of manure and fertilizers were applied to the respective plots marked for giving the nutrient treatments mentioned. The sources of nitrogen, phosphorus and potash were urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. The half dose of nitrogen with full doses of P_2O_5 and K_2O were applied as basal, at the time of transplanting. The remaining dose of N was top dressed at 30 days after transplanting (DAT).

Transplanting

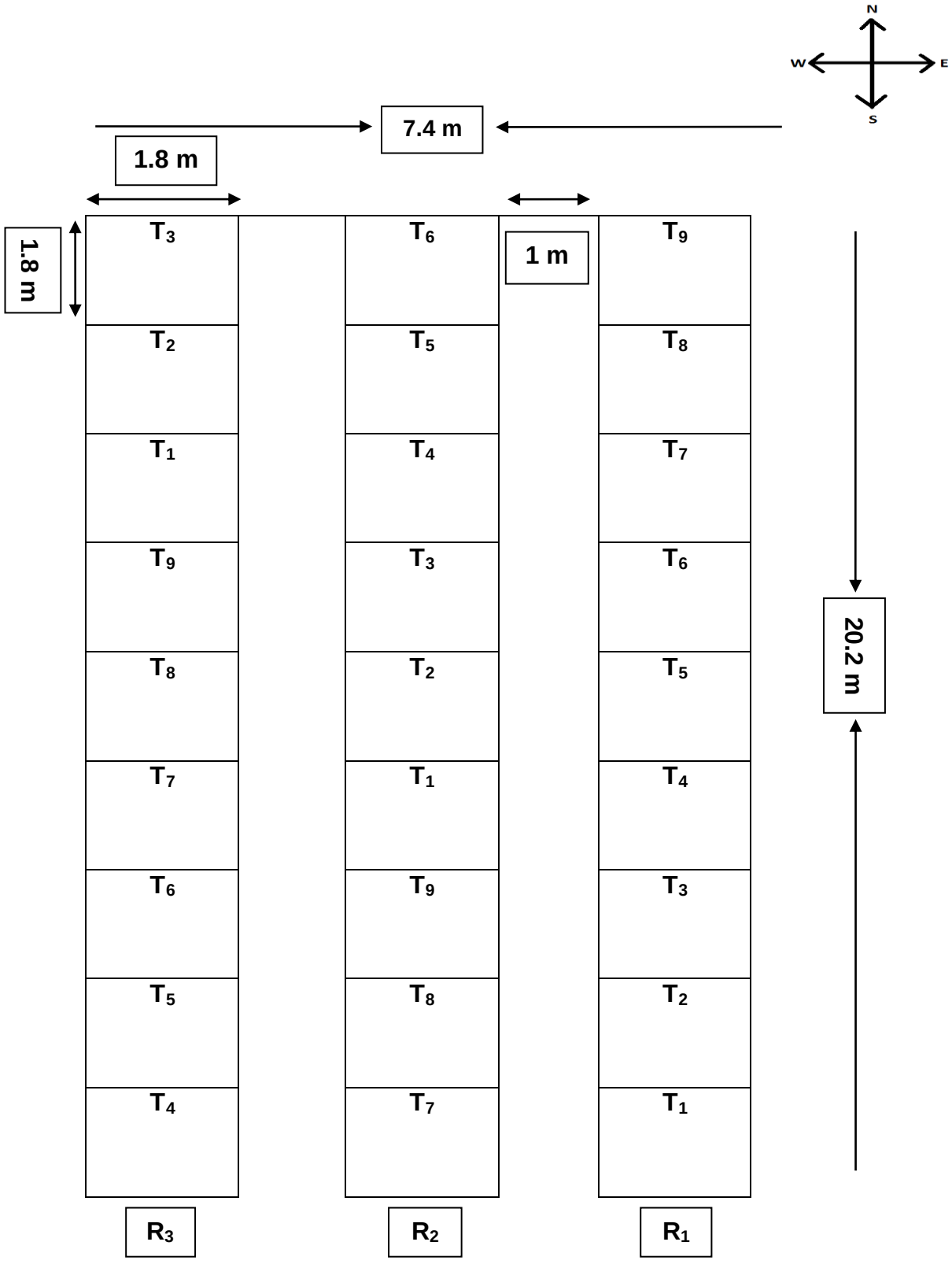
The 30 days old uniform healthy seedlings of Pusa Narangi Gainda were transplanted at a distance of 45 x 45 cm, 45 x 30 cm, 30 x 30 cm in experimental plots on 09th August 2019. The operation of transplanting was carried out in evening and followed by a light irrigation with a view to encourage the establishment of seedlings.

Gap filling

Those seedlings, which died within the first five days of transplanting, were replaced by new ones to maintain uniform crop stand in all the plots.

Fig 3.4: Experimental design and layout

The description of design and layout is as follows



Irrigation

This experiment was conducted in during July 2018 to February 2019.Irrigation was given after 10-15 days interval depending upon the rainfall and soil moisture conditions.

Weeding

Two hand weeding were given to remove the weeds during the entire growth period by Khurpi and kudali.

Plant protection

Mancozeb @ 0.25% was sprayed as a prophylactic measure for control of leaf blight and spot disease and wettable sulphur 80% w/w @ 0.3% was dusted to control powdery mildew of marigold. Spraying of Trizophos 40EC @ 2 ml/litre of water was given to control the attack of hairy catterpiller and Nuvacron 40EC @ 1ml/l of water was given to control the attack of sucking pests like aphids, thrips, and mites 30 and 60 days after transplanting.

Harvesting

Fully-opened flowers were plucked in the morning by hand. Field was irrigated beforeplucking to maintain turgidity of flowers and better post-harvest life. After harvesting,flowers were kept in shade with proper ventilation facility. Then, they were graded on thebasis of size. The bruised and deformed flowers were discarded. The packing of flowers were done in polythene bags or bamboo baskets.

Table 3.5: Schedule of operations carried out in course of Investigation

Operation	Date	Remark
Nursery raising (seed sowing)	9 July	Manually
Field operation (a) Ploughings(two) (b) Harrowing	 25 July 1 August	 By tractor
Soil sample collection for physio-chemical studies of the soil before transplanting	1 August	Hand Auger
Layout	05 August	Manually
Manure and fertilizer application	08 August	Manually
Transplanting	09 August	Manually
Gap filling	14 August	Manually
Observations recorded	As per requirement	Manually
Irrigation (a) First (b) Second (c) Third (d) Fourth (e) Fifth (f) Sixth (g) Seventh (h) Eighth (i) Ninth (j) Tenth	 09 August 20 August 05 September 19September 04October 20October 9 November 20 November 10 December 01 January	Manually
Intercultural Weeding and hoeing-I Weeding and hoeing-II	 22 August 1 October	 By Khurpi and Kudali
Plant protection (a) Insecticide and fungicidespray-I (b) Insecticide and fungicidespray-II (c) Insecticide and fungicidespray-III	 25 September 10 October 25 October	By Sprayer

Observations recorded

For growth, flowering and yield parameters, five plants were randomly selected from each plot of all the replications. The procedures for recording the data are mentioned with appropriate headings.

A.Growth Parameters (at 60 DAT)

1. Plant height (cm)

The height of five selected plants was measured in cm from the soil surface up to the terminal top portion of the plant with the help of a meter scale at 60days after transplanting and their mean was calculated.

2. Plant Spread (cm)

Plant spread was calculated by measuring the spread of foliage in East-West and North-south direction at 60 DAT with the help of meter scale in cm and their mean was calculated.

3. Number of primary branches/plant

Number of primary branches per plant was counted at 60 DAT.

4. Number of secondary branches/plant

Number of secondary branches per plant was counted 60 DAT.

5. Number of leaves/plant

Number of leaves of five randomly selected plants was counted at 60days after transplanting and means value was calculated as the number of leaves per plant.

6. Stem diameter (cm)

Stem diameter of five selected plants was measured in cm using vernier calipers at just above the soil surface at 60days after transplanting and their mean was estimated.

B. Flowering Parameters

1. Days taken to 1st bud appearance

Number of days taken for the emergence of first bud from the date of transplanting, were counted and averaged.

2. Days taken to 1st flower appearance

Number of days taken for the first flowering from the date of transplanting, were counted and their mean was determined.

3. Bud diameter at full grown stage (cm)

The size of the fully developed flowering buds were measured in cm as diameter of bud with the help of vernier calipers and then averaged.

4. Bud length (cm)

The length of the fully developed flowering buds were measured in cm with the help of cm scale and then averaged.

5. Days taken to 50% flowering

In this observation number of days taken to 50% flowering was counted from the date of transplanting of seedling to the appearance of flower on 50% plants on a single plot.

6.Flower diameter (cm)

Maximum breadth across the flower was taken as the diameter of five flowers per plants and five plants per plot in each treatment and was measured in centimetre by using cm scale and average was worked out.

7. Fresh weight of flower (g)

The Individual flower weight of flowers per plant was measured by means of physical balance and average was calculated.

8. Dry weight of flower (g)

The selected five plants were oven-dried for their dry weights at the final observation and their mean was calculated in gram.

9. Duration of flowering

A regular watching was done on the experimental field. The duration of flowering was calculated on the basis of days of bloom from first anthesis up to the last picking.

C. Post harvest quality and biochemical analysis parameters

1. Chlorophyll content in leaves (SPAD value)

Chlorophyll content was estimated in 4^{th} leaf from the top (fully expended leaf) with the help of chlorophyll meter (SPAD-502 plus) in selected plants. Readings measured in 5 plants per pot at different DAS. Chlorophyll content is expressed in terms of SPAD units.

2. Carotenoid's in petals (mg/g)

Principle:

The total carotenoids are extracted and partitioned in organic solvent such as 80% acetone. The amount of carotenoids is estimated spectrophotometrically at 663 and 645 nm wavelengths.

Materials required:

Plant leaf, distilled water, 80% acetone, mortar and pestle, funnels, Whatman filter papers grade1, volumetric flasks, measuring cylinders, pipettes, spectrpphotometer etc.

Procedure:

Prepare 80% acetone. Weigh 250 mg of fresh petals material, grind the pieces of plant material in pestle and mortar using 5 ml of 80% acetone. Filter the homogenate in 25 ml volumetric flask by using Whatman paper grade 1. Wash out the homogenate 3-4 times with 5 ml of 80% acetone each time. Grind the tissue once again with minimum quantity of acetone if required as it helps in complete extraction of plant pigments. Centrifuge the tubes (2000 rpm) for 10 minutes. Collect the supernatant in 25 ml volumetric flask and makeup the volume with 80% acetone.

Record the absorbance of supernatant at two different wavelengths (663 and 645 nm) using spectrophotometer by keeping 80% acetone as blank.

The total carotenoid content can be calculated by the formula given by Kirk and Allen (1965):

$$C = \{A480 + (0.114 \times A663) – (0.638 \times A645)\}$$

Where, C=Total amount of carotenoids (mg), A480 = Absorbance at 480 nm, A645 = Absorbance at 645 nm and A663 = Absorbance at 663 nm.

3. Flower yield/plant (g)

Flower yield of five observational plants were added and then mean weight was calculated as average yield per plant in gram.

4. Flower yield/plot (kg)

Flower yield per plot was calculated in kg from the flower weight per plant for all the treatments in all replications and then averaged.

5. Flower yield/ha (q)

Flower yield per hectare was calculated in quintal from the flower weight per plot for all the treatments in all replications and then averaged.

D. Seed yield parameters

1.Weight of seed per flower (g)

Seed of per flower was collected from each flower of selected plant and weighed them.

2. 100 seed weight (g)

100 seeds were counted and weighed. The data was recorded in grams.

3. Seed yield per plant (g)

Seed yield per plant was calculated on the basis of weight of seed per flower per plant from each experimental plot.

Statistical analysis

The data obtained on various observations for each treatment were subject to "Analysis of variance" as recommended by Panse and Sukhatme (1984). The skeleton of ANOVA as per design is as follows:

Table 3.6: Skeleton of analysis of variance

Source of variation	Degree of freedom	Sum of square	Mean sum of square	"F" Value Calculated	"F" tab at 5%
Replication	2	SSR	MSR	MSR/ MSE	3.63
Spacing (S)	2	SSS	MSS	MSS/ MSE	3.63
Pinching (P)	2	SSP	MSP	MSP /MSE	3.63
Interaction (S x P)	4	SSSP	MSSP	MSSP /MSE	3.01
Error	16	SSE			
Total	26	SST			

The significance of the treatment difference was judged by using critical difference (C.D.), which was calculated by using formula given by Panse and Sukhatme (1984).

Standard error of mean (S.Em.±):

$$\text{(a) S.Em.}\pm\text{for S} = \sqrt{\frac{EMS}{\text{No. of replication x Levels of P}}}$$

$$\text{(b) S.Em}\pm\text{for P} = \sqrt{\frac{EMS}{\text{No. of replication x Levels of S}}}$$

$$\text{(c) S.Em}\pm\text{ for S}\times\text{P} = \sqrt{\frac{EMS}{\text{No. of replication}}}$$

Critical difference (CD):

(a) CD for S = $S.Em\pm (S) \times \sqrt{2} \times t_{5\% (edf)}$

(b) CD for P = $S.Em\pm (P) \times \sqrt{2} \times t_{5\% (edf)}$

(c) CD for S×P = $S.Em\pm (S\times P) \times \sqrt{2} \times t_{5\% (edf)}$

Where:

R = Number of replications

S = Spacing

P = Pinching

t = 't' Table value at error degree of freedom

EMS = Error mean sum of square

S. Em. = Standard error of mean

CD = Critical difference

Chapter - IV

RESULTS

The present investigation entitled a **"Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching"** was carried out at Research Farm, College of Horticulture, Mandsaur in kharif season of 2018-19. The experimental findings computed on the basis of the observations recorded and statistical analysis are presented precisely in this chapter under the following heads:

4.1 Plant height (cm)

The observation on plant height as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.1 and illustrated in Fig. 4.1.

The plant height at 60 days after transplanting was significantly influenced by the spacing treatments. Plant height for spacing was varied from 63.67 cm to 70.62 cm. The maximum plant height (70.62 cm) was recorded with S_3 (30 x 30 cm) followed by 67.53 cm with S_2 (45 x 30 cm) whereas minimum plant height was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

Similarly, the plant height at 60 days after transplanting was significantly influenced by the pinching treatments. Plant height for pinching was varied from 64.62 cm to 70.09 cm. The maximum plant height (70.09 cm) was recorded with P_0 (no pinching) followed by 67.11 cm with P_1 (single pinching) whereas minimum plant height was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.1) were found to be significant at 60 days after transplanting. Plant height for interaction was varied from 61.47 cm to 74.73 cm. The spacing of 30x30 cm with no pinching (S_3P_0) gave maximum plant height (74.73 cm) which was followed by S_3P_1 (70.87 cm), S_2P_0 (69.27 cm) and S_2P_1 (67.20 cm). Whereas, wider spacing (45x45 cm) with double pinching (S_1P_2) gave minimum plant

height 61.47 cm followed by S_1P_1 (63.27 cm). Both of these treatments are statisticallyat par to each other and differ over rest of the treatments.

Table No. 4.1. Effect of different plant spacing and pinching on plant height

Treatment	Plant height (cm)
Spacing (cm)	
45X45 (S_1)	63.67
45X30 (S_2)	67.53
30X30 (S_3)	70.62
SE (m) ±	**0.46**
CD at 5%	**1.39**
Pinching	
No pinching (P_0)	70.09
Single pinching (P_1)	67.11
Double pinching (P_2)	64.62
SE (m) ±	**0.46**
CD at 5%	**1.39**
Spacing x Pinching	
S_1P_0	66.27
S_1P_1	63.27
S_1P_2	61.47
S_2P_0	69.27
S_2P_1	67.20
S_2P_2	66.13
S_3P_0	74.73
S_3P_1	70.87
S_3P_2	66.27
SE (m) ±	**0.80**
CD at 5%	**2.406**

Fig 4.1.1: Effect of spacing on plant height (cm) of marigold

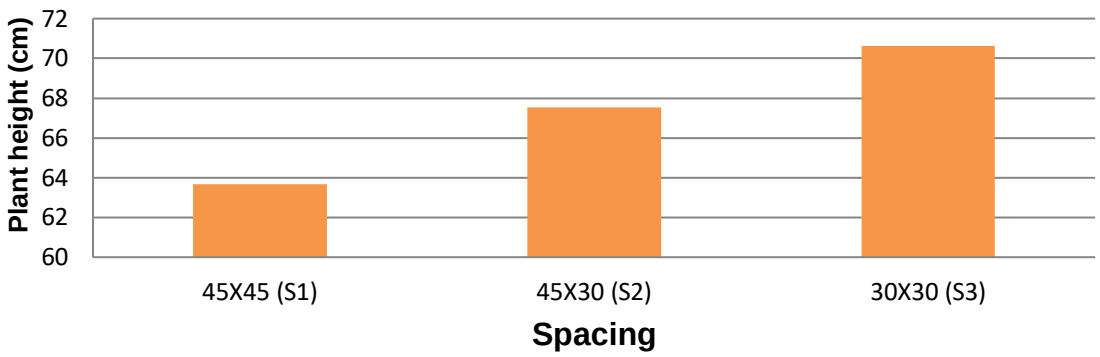


Fig 4.1.2: Effect of pinching on plant height (cm) of marigold

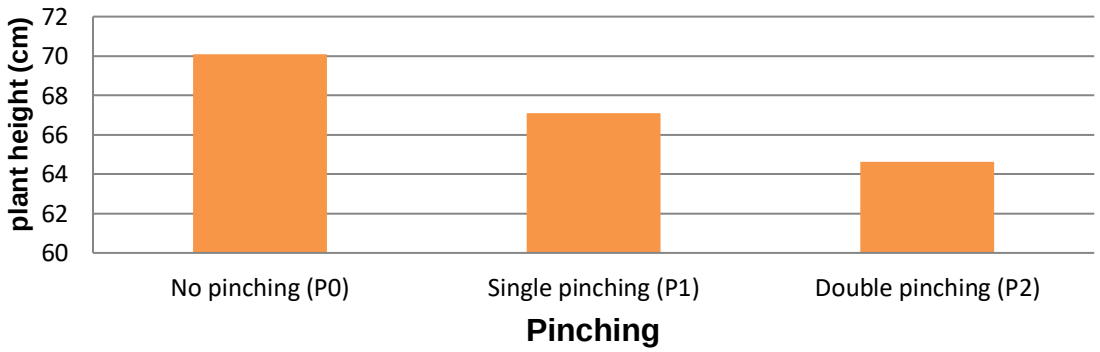
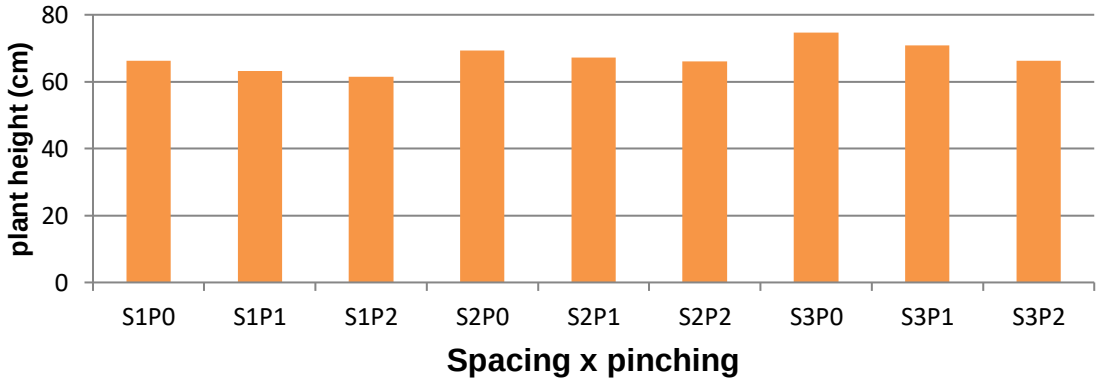


Fig 4.1.3: Effect of interaction on plant height (cm) of marigold



4.2 Plant spread (cm)

The observations on plant spread as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.2 and illustrated in Fig. 4.2.

The plant spread at 60 days after transplanting was significantly influenced by the spacing treatments. Plant spread for spacing was varied from 25.67 cm to 27.29 cm. The maximum plant spread (27.29 cm) was recorded with S_1 (45 x 45 cm). Whereas minimum plant spread 25.67 cm was recorded with S_3 (30 x 30 cm) followed by 25.96 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The plant spread at 60 days after transplanting was significantly influenced by the pinching treatments. Plant spread for pinching was varied from 25.49 cm to 27.10 cm. The maximum plant spread (27.10 cm) was recorded with P_2 (double pinching) followed by 26.32 cm with P_1 (single pinching) and both of these treatment are statistically at par to each other. Whereas the minimum plant spread (25.49 cm) was recorded with P_0 (no pinching).

The interaction effect between spacing and pinching (Table 4.2) were found to be non-significant at 60 days after transplanting. Plant spread for interaction was varied from 25.13 cm to 28.23 cm. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum plant spread (28.23 cm) which was followed by S_1P_1 (27.77 cm), S_2P_2 (26.67 cm) and S_3P_2 (26.40 cm). Whereas, closer spacing (30x30 cm) with no pinching (S_3P_0) gave minimum plant spread 25.13 cm.

Table No. 4.2. Effect of different plant spacing and pinching on plant spread

Treatment	Plant spread (cm)
Spacing (cm)	
45X45 (S_1)	27.29
45X30 (S_2)	25.96
30X30 (S_3)	25.67
SE (m) ±	**0.39**
CD at 5%	**1.16**
Pinching	
No pinching (P_0)	25.49
Single pinching (P_1)	26.32
Double pinching (P_2)	27.10
SE (m) ±	**0.39**
CD at 5%	**1.16**
Spacing x Pinching	
S_1P_0	25.87
S_1P_1	27.77
S_1P_2	28.23
S_2P_0	25.47
S_2P_1	25.73
S_2P_2	26.67
S_3P_0	25.13
S_3P_1	25.47
S_3P_2	26.40
SE (m) ±	**0.67**
CD at 5%	**NS**

Fig 4.2.1: Effect of spacing on plant spread (cm) of marigold

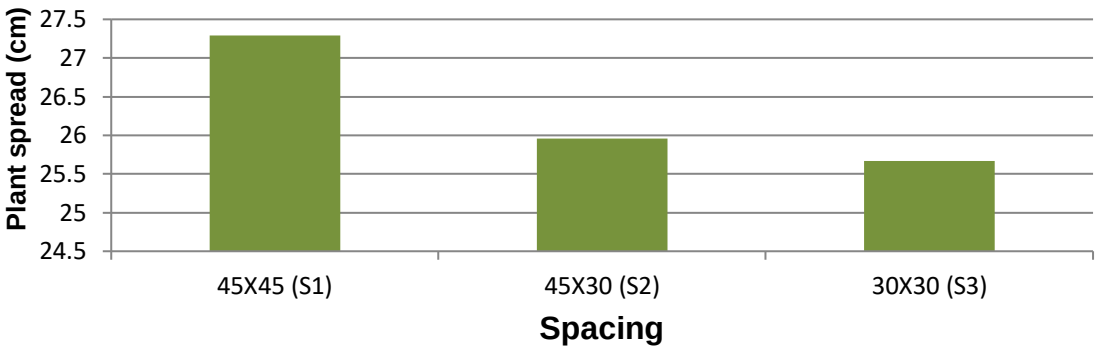


Fig 4.2.2: Effect of pinching on plant spread (cm) of marigold

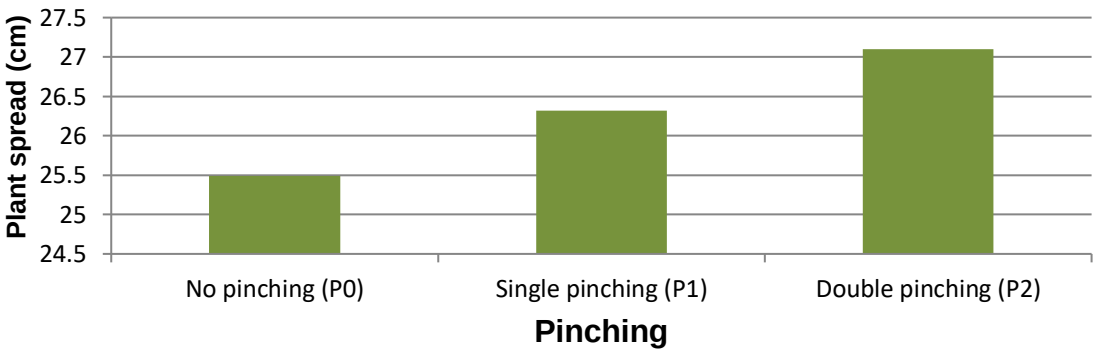
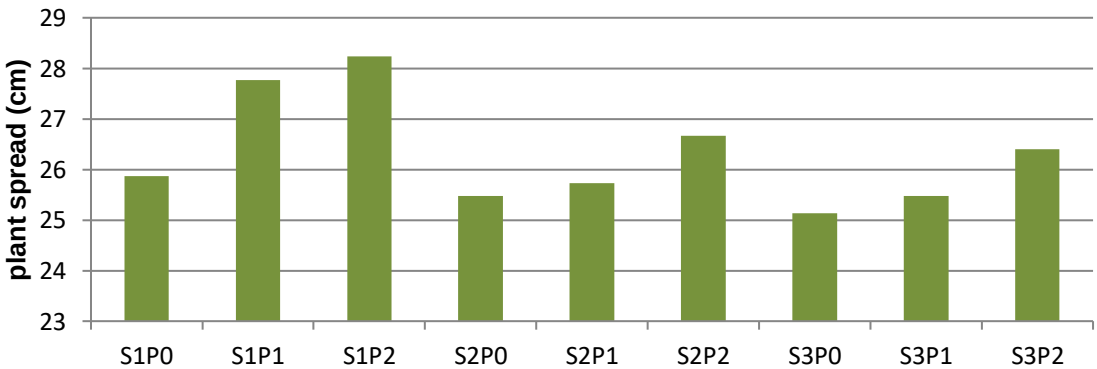


Fig 4.2.3: Effect of interaction on plant spread (cm) of marigold



4.3 Number of primary branches per plant

The observations on number of primary branches per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.3 and illustrated in Fig. 4.3.

The number of primary branches per plantat 60 days after transplanting was significantly influenced by the spacing treatments. Number of primary branches per plantfor spacing was varied from 12.22 to 13.33. The maximum number of primary branches per plant(13.33) were recorded with S_1 (45 x 45 cm) followed by 12.67 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum number of primary branches per plant were recorded with S_3 (30 x 30 cm).

Similarly, the number of primary branches per plantat 60 days after transplanting was significantly influenced by the pinching treatments. Number of primary branches per plantfor pinching was varied from 11.76 to 14.16. The maximum number of primary branches per plant(14.16) was recorded with P_3 (double pinching) which was statistically superior to other treatments. Whereas, the minimum number of primary branches per plant 11.76 were recorded with P_0 (no pinching) followed by 12.31 with P_1 (single pinching) and both of these treatments are statistically at par to each other.

The interaction effect between spacing and pinching (Table 4.3) were found to be non-significant at 60 days after transplanting. Number of primary branches per plantfor interaction was varied from 11.47 to 15.40. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum number of primary branches per plant(15.40) which was followed by S_2P_2 (14.07), S_3P_2 (13.00) and S_1P_1 (12.47). Whereas, closer spacing (30x30 cm) with no pinching (S_3P_0) gave minimum number of primary branches per plant 11.47.

Table No. 4.3. Effect of different plant spacing and pinching on number of primary branches per plant

Treatment	Number of primary branches per plant
Spacing (cm)	
45X45 (S_1)	13.33
45X30 (S_2)	12.67
30X30 (S_3)	12.22
SE (m) ±	**0.23**
CD at 5%	**0.69**
Pinching	
No pinching (P_0)	11.76
Single pinching (P_1)	12.31
Double pinching (P_2)	14.16
SE (m) ±	**0.23**
CD at 5%	**0.69**
Spacing x Pinching	
S_1P_0	12.13
S_1P_1	12.47
S_1P_2	15.40
S_2P_0	11.67
S_2P_1	12.27
S_2P_2	14.07
S_3P_0	11.47
S_3P_1	12.20
S_3P_2	13.00
SE (m) ±	**0.40**
CD at 5%	**NS**

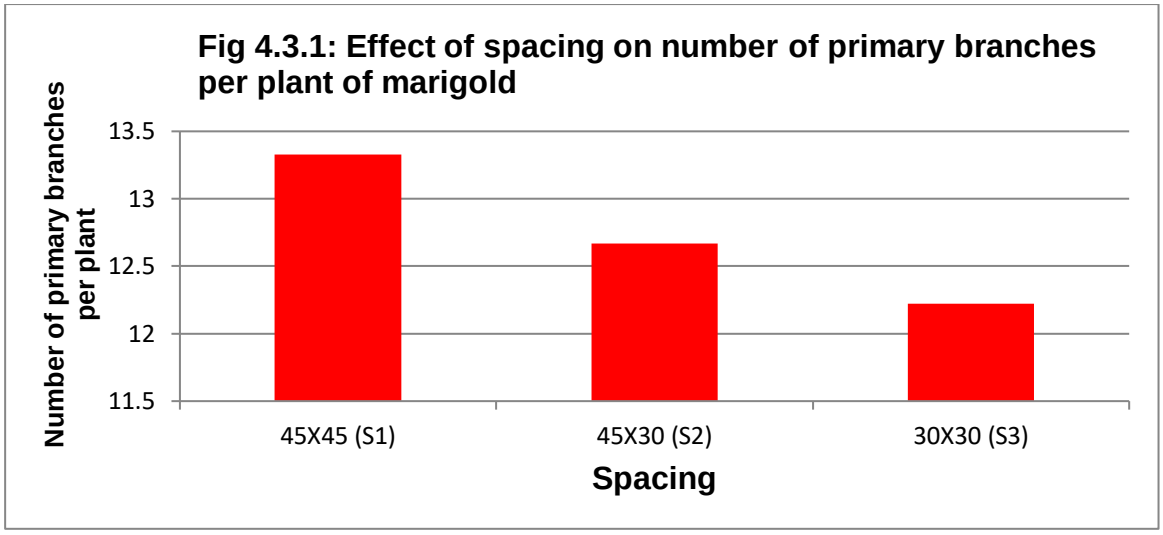


Fig 4.3.1: Effect of spacing on number of primary branches per plant of marigold
Number of primary branches per plant
13.5
13
12.5
12
11.5
45X45 (S1)
45X30 (S2)
30X30 (S3)
Spacing

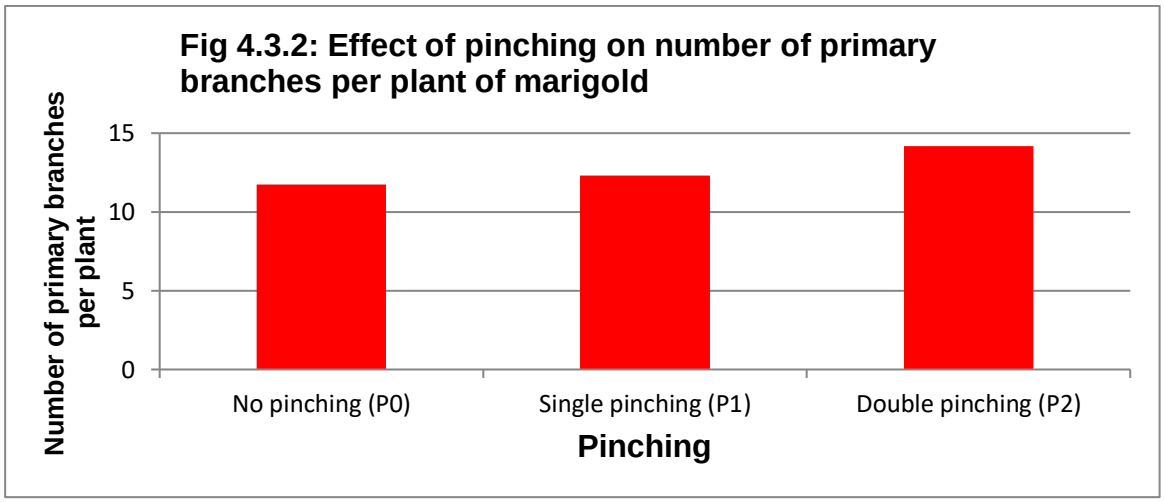


Fig 4.3.2: Effect of pinching on number of primary branches per plant of marigold
Number of primary branches per plant
15
10
5
0
No pinching (P0)
Single pinching (P1)
Double pinching (P2)
Pinching

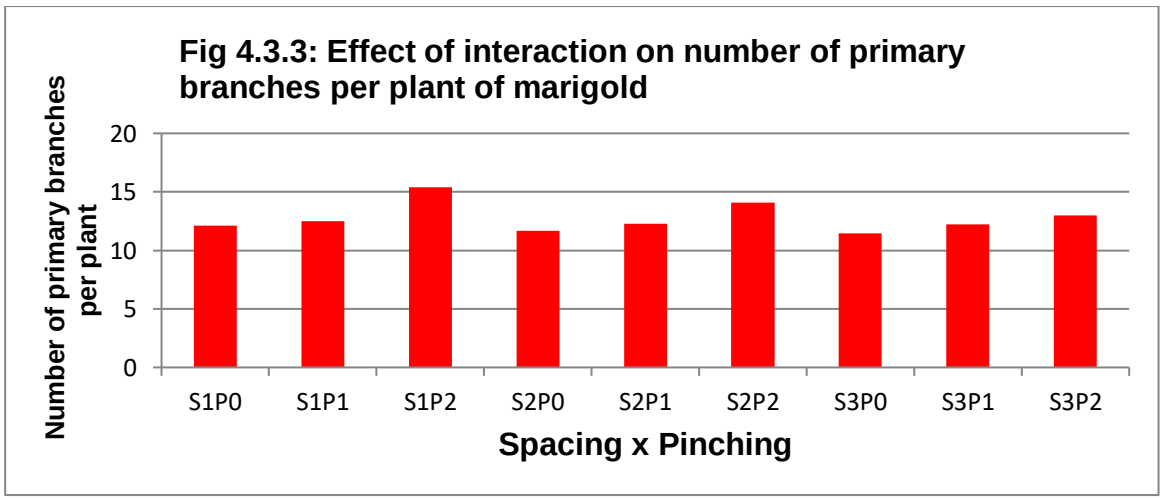


Fig 4.3.3: Effect of interaction on number of primary branches per plant of marigold
Number of primary branches per plant
20
15
10
5
0
S1P0
S1P1
S1P2
S2P0
S2P1
S2P2
S3P0
S3P1
S3P2
Spacing x Pinching

4.4 Number of secondary branches per plant

The observations on number of secondary branches per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.4 and illustrated in Fig. 4.4.

The number of secondary branches per plantat 60 days after transplanting was significantly influenced by the spacing treatments. Number of secondary branches per plantfor spacing was varied from 24.73 to 26.27. The maximum number of secondary branches per plant(26.27) was recorded with S_1 (45 x 45 cm) which was statistically superior to other treatments. Whereas minimum number of secondary branches per plant 24.73 were recorded with S_3 (30 x 30 cm) followed by 24.93 with S_2 (45 x 30 cm) and both of these treatments are statistically at par to each other.

The number of secondary branches per plantat 60 days after transplanting was significantly influenced by the pinching treatments. Number of secondary branches per plantfor pinching was varied from 19.42 to 32.47. The maximum number of secondary branches per plant (32.47) was recorded with P_2 (double pinching) followed by 24.04 with P_1 (single pinching). Whereas minimum number of secondary branches per plant 19.42 were recorded with P_0 (no pinching).

The interaction effect between spacing and pinching (Table 4.4) were found to be significant at 60 days after transplanting. Number of secondary branches per plantfor interaction was varied from 18.67 to 33.40. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum number of secondary branches per plant(33.40)and it was statistically superior to other treatments, followed by S_2P_2 (32.07), S_3P_2 (31.93) and S_2P_1 (24.47). Whereas, closer spacing (30x30 cm) with no pinching (S_3P_0) and spacing (45x30 cm) with no pinching (S_2P_0) gave minimum number of secondary branches per plant 18.67.

Table No. 4.4. Effect of different plant spacing and pinching on number of secondary branches per plant

Treatment	Number of secondary branches per plant
Spacing (cm)	
45X45 (S_1)	26.27
45X30 (S_2)	24.93
30X30 (S_3)	24.73
SE (m) ±	**0.15**
CD at 5%	**0.45**
Pinching	
No pinching (P_0)	19.42
Single pinching (P_1)	24.04
Double pinching (P_2)	32.47
SE (m) ±	**0.15**
CD at 5%	**0.45**
Spacing x Pinching	
S_1P_0	20.93
S_1P_1	24.47
S_1P_2	33.40
S_2P_0	18.67
S_2P_1	24.07
S_2P_2	32.07
S_3P_0	18.67
S_3P_1	23.60
S_3P_2	31.93
SE (m) ±	**0.26**
CD at 5%	**0.777**

Fig 4.4.1: Effect of spacing on number of secondary branches per plant of marigold

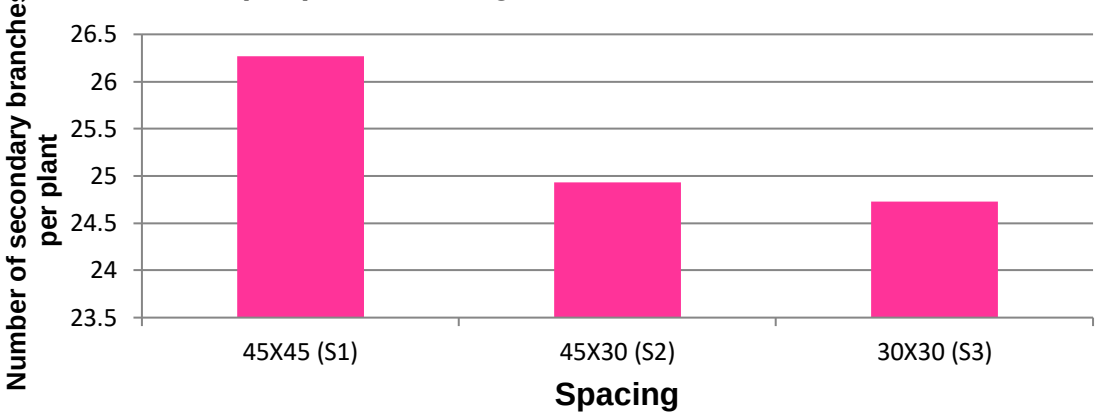


Fig 4.4.2: Effect of pinching on number of secondary branches per plant of marigold

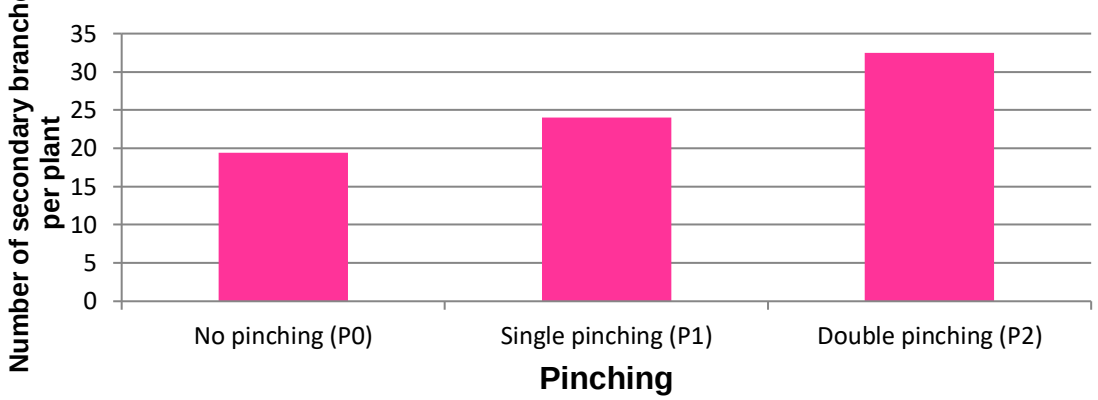
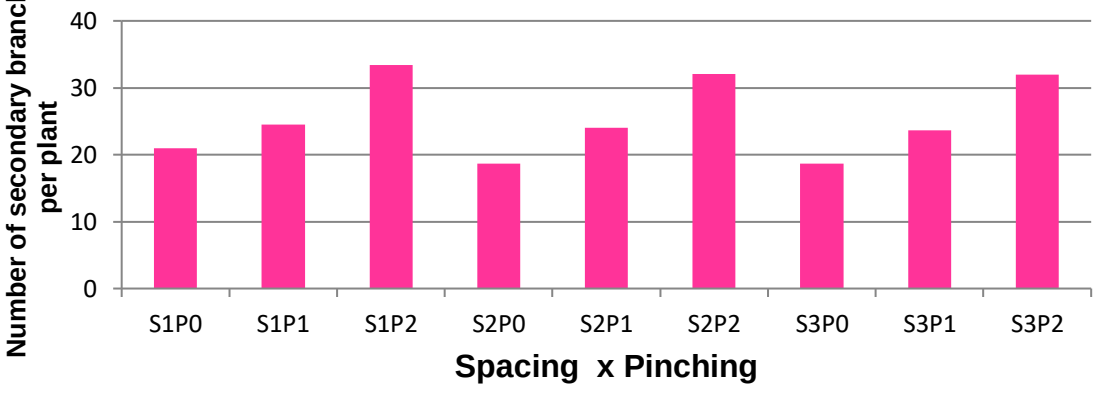


Fig 4.4.3: Effect of interaction on number of secondary branches per plant of marigold



4.5 Number of leaves per plant

The observations on number of leaves per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.5 and illustrated in Fig. 4.5.

The number of leaves per plantat 60 days after transplanting was significantly influenced by the spacing treatments. Number of leaves per plantfor spacing was varied from 225.66 to 265.03. The maximum number of leaves per plant(265.03) was recorded with S_1 (45 x 45 cm) followed by 245.69 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum number of leaves per plant225.66 were recorded with S_3 (30 x 30 cm).

Similarly, the number of leaves per plantat 60 days after transplanting was significantly influenced by the pinching treatments. Number of leaves per plantfor pinching was varied from 209.39 to 285.94 .The maximum number of leaves per plant285.94 was recorded with P_2 (double pinching) followed by 241.04 with P_1 (single pinching). Whereas the minimum number of leaves per plant209.39 were recorded with P_0 (no pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.5) were found to be non-significant at 60 days after transplanting. Number of leaves per plantfor interaction was varied from 193.67 to 306.77. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum number of leaves per plant306.77 which was followed by S_2P_2 (280.73), S_3P_2 (270.33) and S_1P_1 (261.50). Whereas, spacing (30x30 cm) with no pinching (S_3P_0) gave minimum number of leaves per plant(193.67).

Table No. 4.5. Effect of different plant spacing and pinching on number of leaves per plant

Treatment	Number of leaves per plant
Spacing (cm)	
45X45 (S_1)	265.03
45X30 (S_2)	245.69
30X30 (S_3)	225.66
SE (m) ±	**9.22**
CD at 5%	**27.64**
Pinching	
No pinching (P_0)	209.39
Single pinching (P_1)	241.04
Double pinching (P_2)	285.94
SE (m) ±	**9.22**
CD at 5%	**27.64**
Spacing x Pinching	
S_1P_0	226.83
S_1P_1	261.50
S_1P_2	306.77
S_2P_0	207.67
S_2P_1	248.67
S_2P_2	280.73
S_3P_0	193.67
S_3P_1	212.97
S_3P_2	270.33
SE (m) ±	**15.97**
CD at 5%	**NS**

Fig 4.5.1: Effect of spacing on number of leaves per plant of marigold

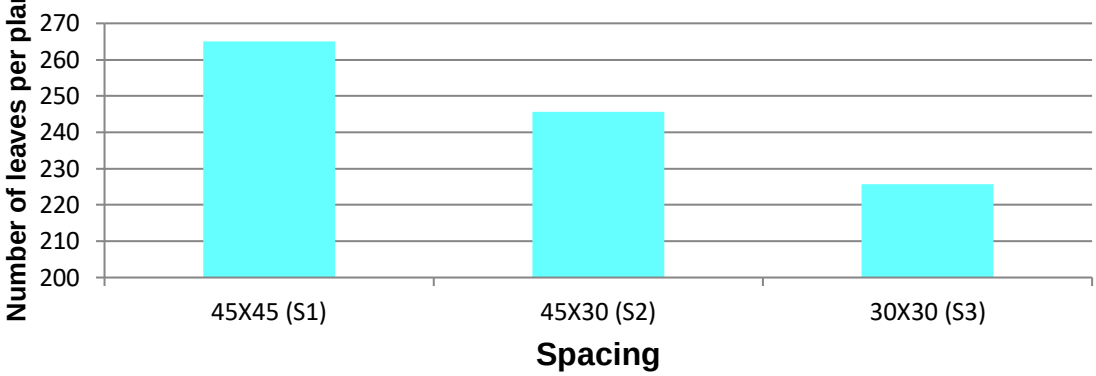


Fig 4.5.2: Effect of pinching on number of leaves per plant of marigold

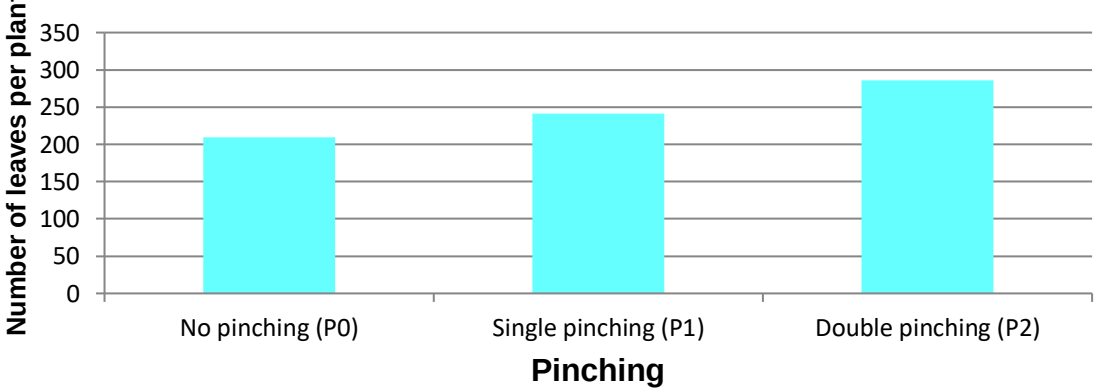
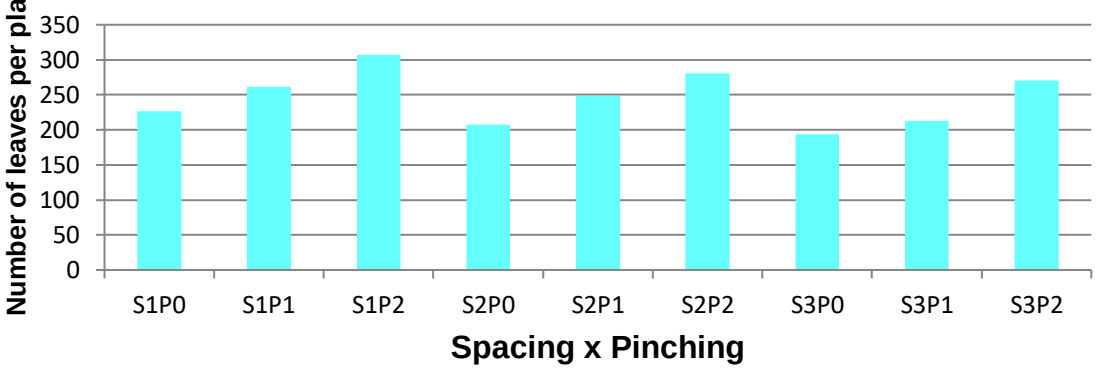


Fig 4.5.3: Effect of interaction on number of leaves per plant of marigold



4.6 Stem diameter (cm)

The observation on stem diameteras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.6 and illustrated in Fig. 4.6.

The stem diameter at 60 days after transplanting was significantly influenced by the spacing treatments. Stem diameter for spacing was varied from 1.01 cm to 1.09 cm. The maximum stem diameter (1.09 cm) was recorded with S_1 (45x45 cm) followed by 1.06 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum stem diameter(1.01 cm) was recorded with S_3 (30x30 cm).

The stem diameter at 60 days after transplanting was non-significantly influenced by the pinching treatments. Stem diameter for pinching was varied from 1.03 cm to 1.08 cm. The maximum stem diameter (1.08 cm) was recorded with P_2 (double pinching) followed by 1.06 cm with P_1 (single pinching). Whereas the minimum stem diameter(1.03 cm) was recorded with P_0 (no pinching).

The interaction effect between spacing and pinching (Table 4.6) were found to be non-significant at 60 days after transplanting. Stem diameter for interaction was varied from 1.0 cm to 1.11 cm. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum stem diameter 1.11 cm which was followed by S_1P_1 (1.10 cm), S_2P_2 (1.08 cm) and S_2P_1 (1.07 cm). Whereas, spacing (30x30 cm) with no pinching (S_3P_0) and spacing (30x30 cm) with single pinching (S_3P_1) gave minimum stem diameter (1.00 cm).

Table No. 4.6. Effect of different plant spacing and pinching on stem diameter

Treatment	Stem diameter (cm)
Spacing (cm)	
45X45 (S_1)	1.09
45X30 (S_2)	1.06
30X30 (S_3)	1.01
SE (m) ±	**0.02**
CD at 5%	**0.05**
Pinching	
No pinching (P_0)	1.03
Single pinching (P_1)	1.06
Double pinching (P_2)	1.08
SE (m) ±	**0.02**
CD at 5%	**NS**
Spacing x Pinching	
S_1P_0	1.06
S_1P_1	1.10
S_1P_2	1.11
S_2P_0	1.02
S_2P_1	1.07
S_2P_2	1.08
S_3P_0	1.00
S_3P_1	1.00
S_3P_2	1.04
SE (m) ±	**0.03**
CD at 5%	**NS**

Fig 4.6.1: Effect of spacing on stem diameter (cm) of marigold

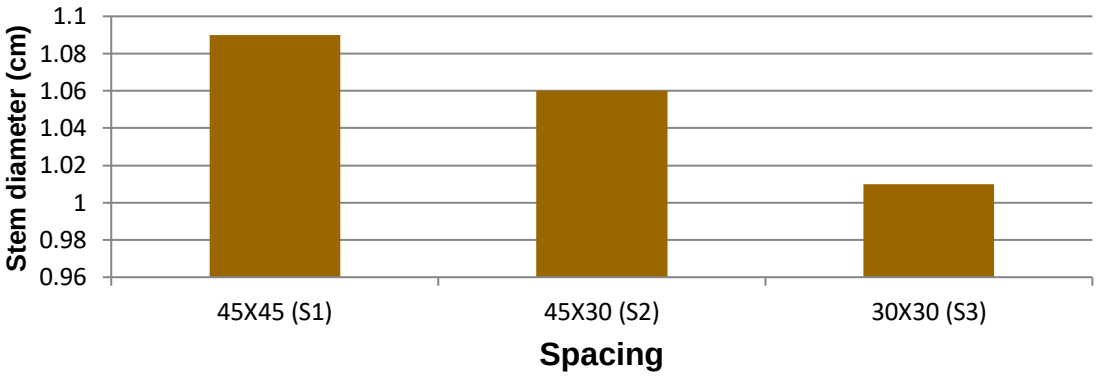


Fig 4.6.2: Effect of pinching on stem diameter (cm) of marigold

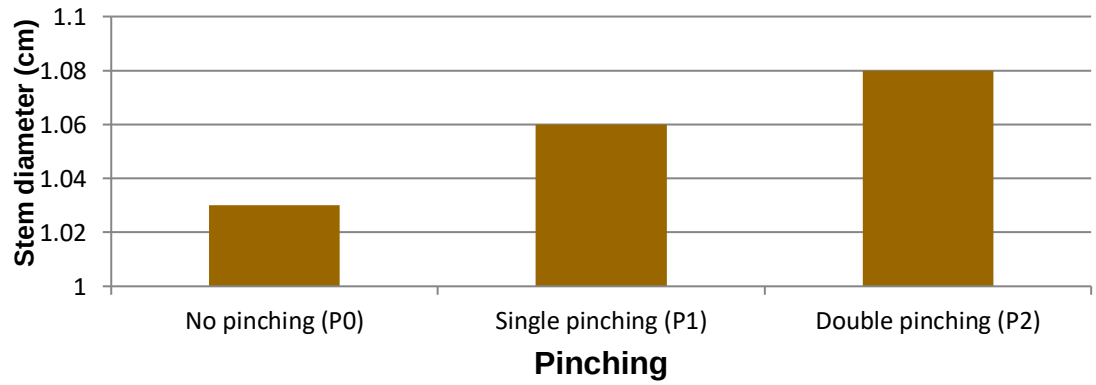
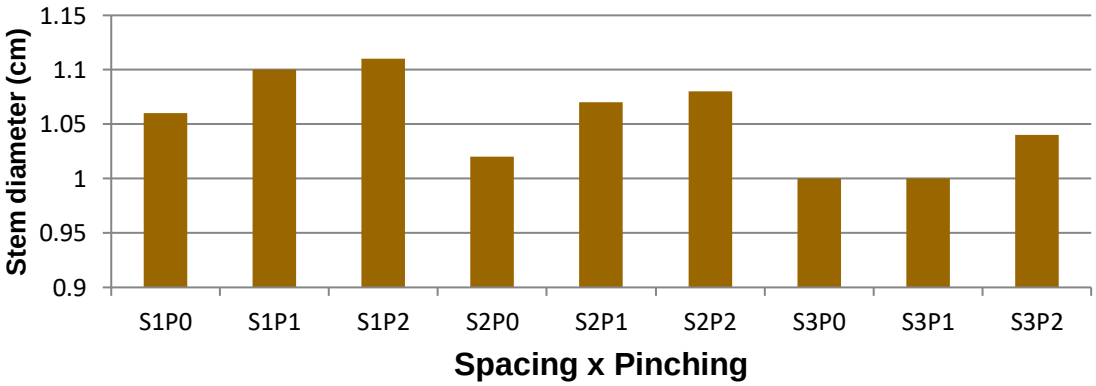


Fig 4.6.3: Effect of interaction on stem diameter (cm) of marigold



4.7 Days taken to first bud appearance

The observations on days taken to first bud appearance as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.7 and illustrated in Fig. 4.7.

The days taken to first bud appearance was significantly influenced by the spacing treatments. Days taken to first bud appearance for spacing were varied from 47.67 to 50.44 days. The minimum days taken to first bud appearance 47.67 days was recorded with S_3 (30 x30 cm) followed by 48.44 days with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other and superior over S_1 (45 x 45 cm) which took maximum days to first bud appearance (50.44 days).

The days taken to first bud appearance was non-significantly influenced by the pinching treatments. Days taken to first bud appearance for pinching were varied from 47.89 to 50.00. The minimum days taken to first bud appearance (47.89 days) was recorded with P_0 (no pinching) followed by 48.67 days with P_1 (single pinching). Whereas the maximum days taken to first bud appearance 50.00 days was recorded with P_2 (double pinching).

The interaction effect between spacing and pinching (Table 4.7) were found to be non-significant. Days taken to first bud appearance for interaction were varied from 47.33 to 51.67 days. However, comparatively less time (47.33 days) was required in the treatment combination of spacing (45x30 cm) with no pinching (S_2P_0) and spacing (30x30 cm) with no pinching (S_3P_0) followed by S_2P_1 (47.67 days), S_3P_1 (47.67 days) and S_3P_2 (48.00 days) while more periods (51.67 days) was taken in wider spacing (45x45 cm) with double pinching (S_1P_2) for first bud appearance.

Table No. 4.7. Effect of different plant spacing and pinching on Days taken to first bud appearance

Treatment	Days taken to first bud appearance
Spacing (cm)	
45X45 (S_1)	50.44
45X30 (S_2)	48.44
30X30 (S_3)	47.67
SE (m) ±	**0.66**
CD at 5%	**1.97**
Pinching	
No pinching (P_0)	47.89
Single pinching (P_1)	48.67
Double pinching (P_2)	50.00
SE (m) ±	**0.66**
CD at 5%	**NS**
Spacing x Pinching	
S_1P_0	49.00
S_1P_1	50.67
S_1P_2	51.67
S_2P_0	47.33
S_2P_1	47.67
S_2P_2	50.33
S_3P_0	47.33
S_3P_1	47.67
S_3P_2	48.00
SE (m) ±	**1.14**
CD at 5%	**NS**

Fig 4.7.1: Effect of spacing on days taken to first bud appearance of marigold

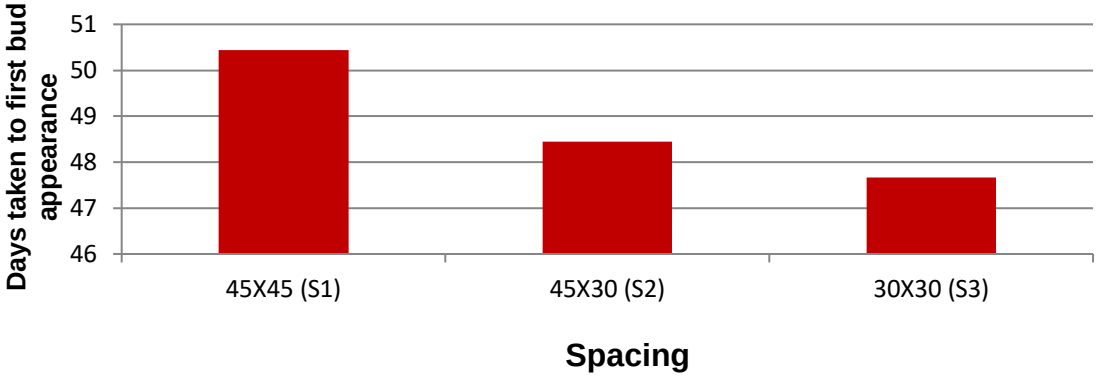


Fig 4.7.2: Effect of pinching on days taken to first bud appearance of marigold

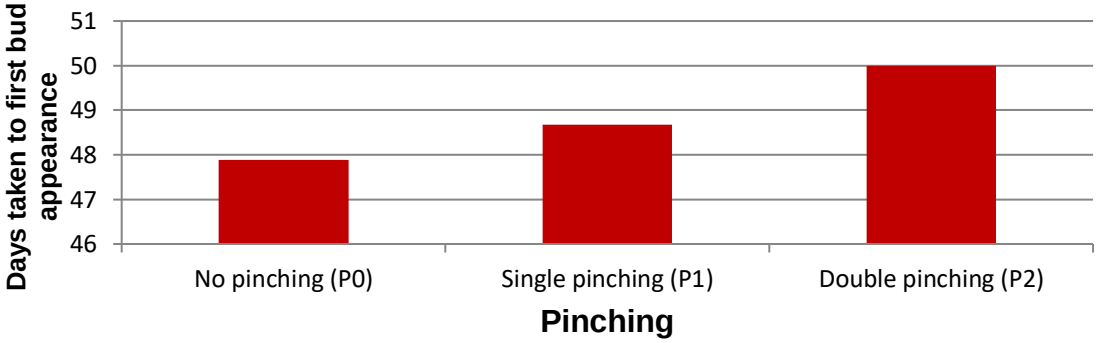
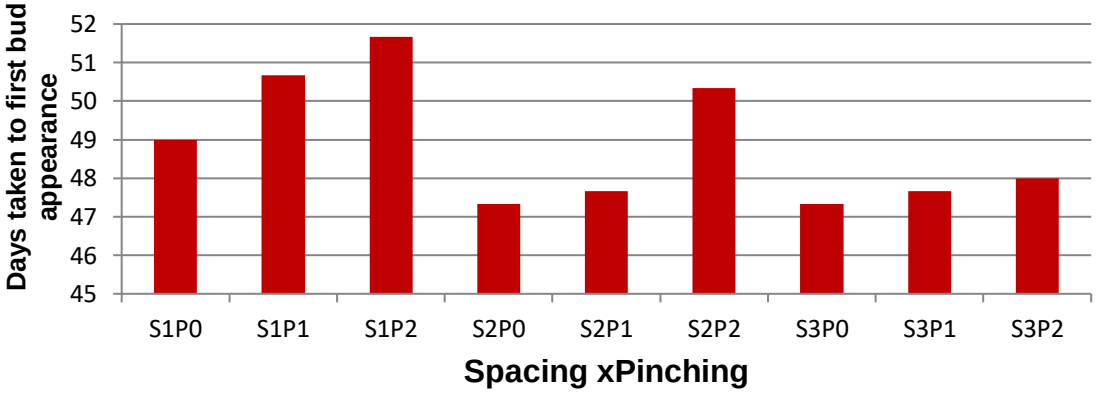


Fig 4.7.3: Effect of interaction on days taken to first bud appearance of marigold



4.8 Bud diameter at full grown stage (cm)

The observations on bud diameter at full grown stageas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.8 and illustrated in Fig. 4.8.

The bud diameter at full grown stagewas significantly influenced by the spacing treatments. Bud diameter at full grown stagefor spacing was varied from 0.87 cm to 0.96 cm. The maximum bud diameter at full grown stage(0.96 cm) was recorded with S_1 (45 x 45 cm) and it was superior over other treatments. Whereas the minimum bud diameter at full grown stage (0.87 cm) was recorded with S_3 (30 x 30 cm) followed by 0.89 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The bud diameter at full grown stagewas significantly influenced by the pinching treatments. Bud diameter at full grown stagefor pinching was varied from 0.89 cm to 0.93 cm. The maximum bud diameter at full grown stage(0.93 cm) was recorded with P_0 (no pinching) followed by 0.90 cm with P_1 (single pinching). Whereas the minimum bud diameter at full grown stage (0.89 cm) was recorded with P_2 (no pinching).

The interaction effect between spacing and pinching (Table 4.8) were found to be non-significant. Bud diameter at full grown stagefor interaction was varied from 0.86 cm to 0.98 cm. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum bud diameter at full grown stage0.98 cm which was followed by S_1P_1 (0.97 cm), S_2P_0 (0.94 cm) and S_1P_2 (0.93 cm). Whereas, spacing (30x30 cm) with double pinching (S_3P_2) gave minimum bud diameter at full grown stage0.86 cm.

Table No. 4.8. Effect of different plant spacing and pinching on bud diameter at full grown stage

Treatment	Bud diameter at full grown stage
Spacing (cm)	
45X45 (S_1)	0.96
45X30 (S_2)	0.89
30X30 (S_3)	0.87
SE (m) ±	**0.01**
CD at 5%	**0.04**
Pinching	
No pinching (P_0)	0.93
Single pinching (P_1)	0.90
Double pinching (P_2)	0.89
SE (m) ±	**0.01**
CD at 5%	**0.04**
Spacing x Pinching	
S_1P_0	0.98
S_1P_1	0.97
S_1P_2	0.93
S_2P_0	0.94
S_2P_1	0.87
S_2P_2	0.87
S_3P_0	0.88
S_3P_1	0.87
S_3P_2	0.86
SE (m) ±	**0.02**
CD at 5%	**NS**

Fig 4.8.1: Effect of spacing on bud diameter at full grown stage of marigold

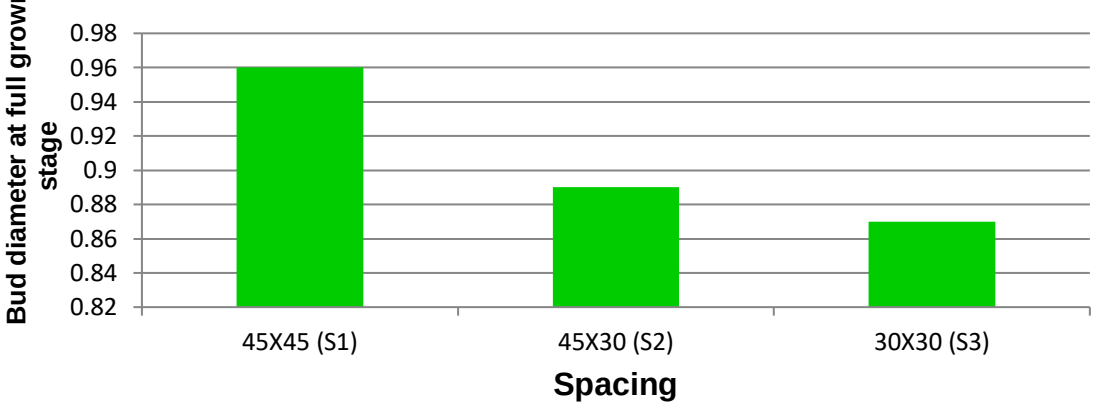


Fig 4.8.2: Effect of pinching on bud diameter at full grown stage of marigold

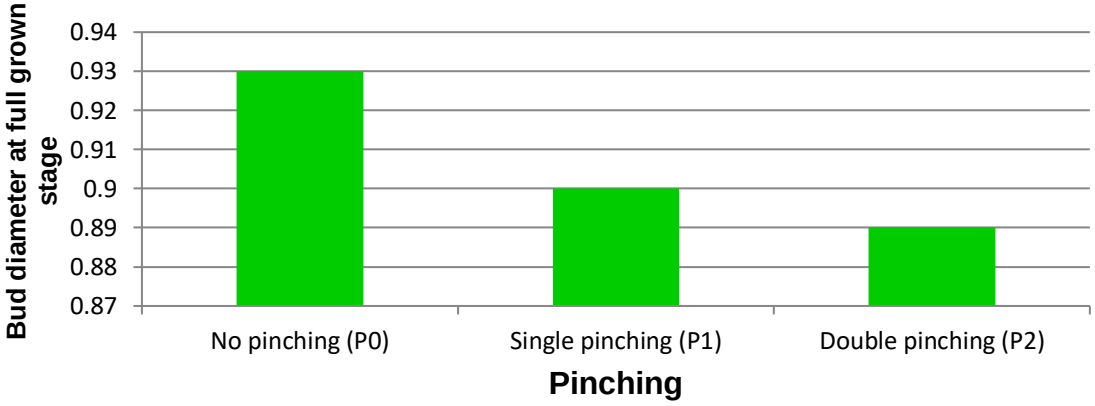
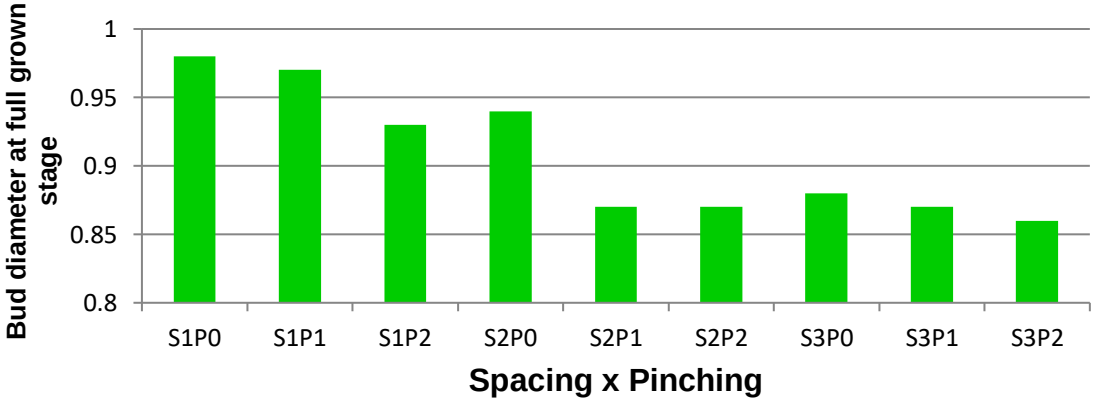


Fig 4.8.3: Effect of interaction on bud diameter at full grown stage of marigold



4.9 Bud length (cm)

The observation on bud length as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.9 and illustrated in Fig. 4.9.

The bud lengthwas significantly influenced by the spacing treatments. Bud lengthfor spacing was varied from 1.69 cm to 1.73 cm. The maximum bud length (1.73 cm) was recorded with S_3 (30 x 30 cm) followed by 1.72 cm with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other. Whereas the minimum bud length 1.69 cm was recorded with S_1 (45 x 45 cm).

The bud lengthwas significantly influenced by the pinching treatments. Bud lengthfor pinching was varied from 1.65 cm to 1.76 cm. The maximum bud length(1.76 cm) was recorded with P_2 (double pinching) followed by 1.73 cm with P_1 (single pinching) and both of these treatments were statistically at par to each other and superior over P_0 (1.65 cm).

The interaction effect between spacing and pinching (Table 4.9) were found to be non-significant. Bud lengthfor interaction was varied from 1.59 cm to 1.78 cm. The spacing of 30x30 cm with double pinching (S_3P_2) gave maximum bud length(1.78 cm) which was followed by S_2P_2 (1.76 cm), S_1P_2 (1.75 cm) and S_3P_1 (1.73 cm). Whereas, spacing (45x45 cm) with no pinching (S_1P_0) gave minimum bud length(1.59 cm).

Table No. 4.9. Effect of different plant spacing and pinching on bud length (cm)

Treatment	Bud length (cm)
Spacing (cm)	
45X45 (S_1)	1.69
45X30 (S_2)	1.72
30X30 (S_3)	1.73
SE (m) ±	**0.01**
CD at 5%	**0.03**
Pinching	
No pinching (P_0)	1.65
Single pinching (P_1)	1.73
Double pinching (P_2)	1.76
SE (m) ±	**0.01**
CD at 5%	**0.03**
Spacing x Pinching	
S_1P_0	1.59
S_1P_1	1.71
S_1P_2	1.75
S_2P_0	1.67
S_2P_1	1.73
S_2P_2	1.76
S_3P_0	1.68
S_3P_1	1.73
S_3P_2	1.78
SE (m) ±	**0.02**
CD at 5%	**NS**

Fig 4.9.1: Effect of spacing on bud length (cm) of marigold

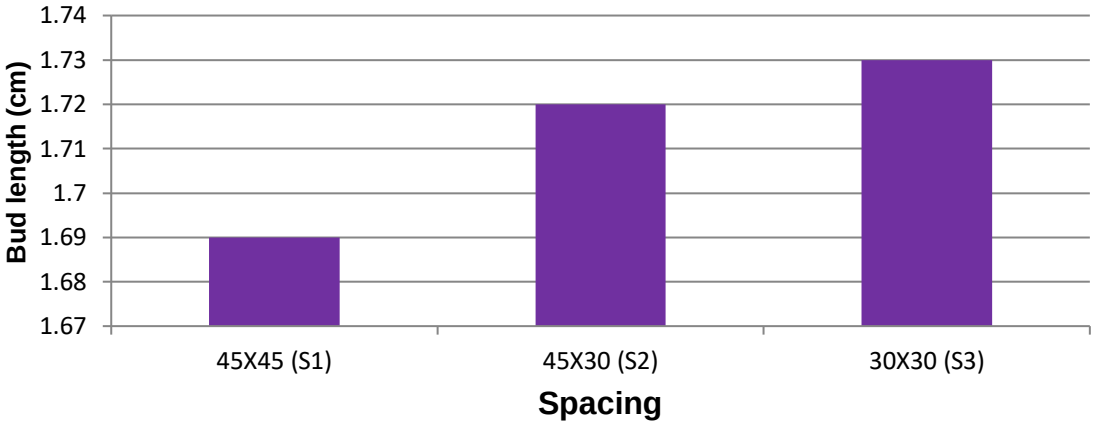


Fig 4.9.2: Effect of pinching on bud length (cm) of marigold

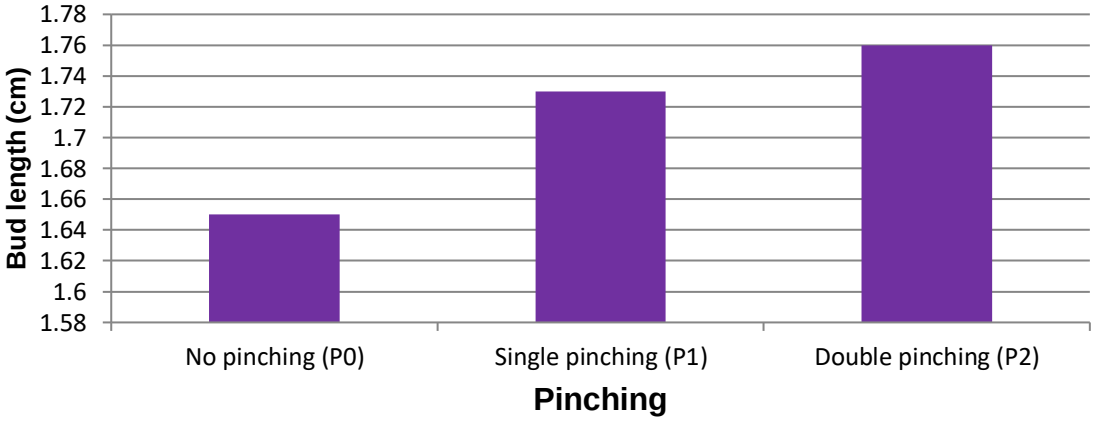
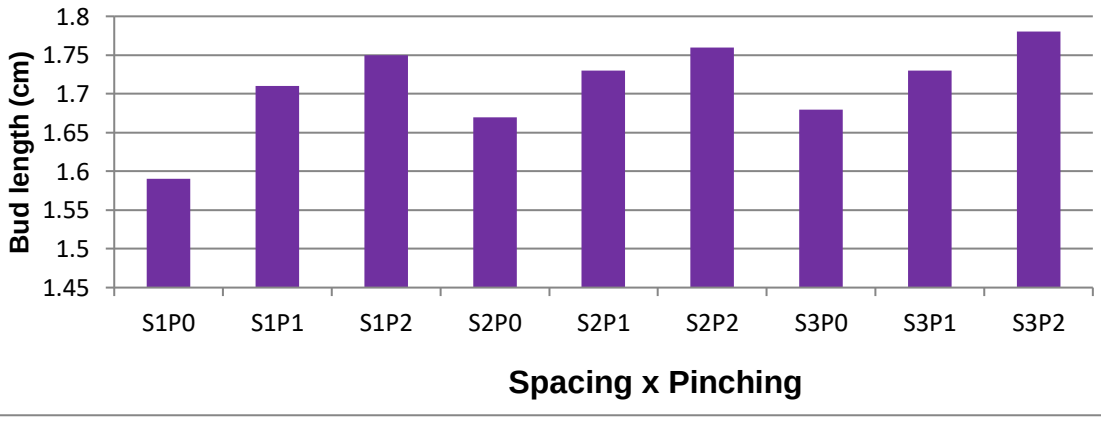


Fig 4.9.2: Effect of interaction on bud length (cm) of marigold



4.10 Days taken to first flower opening

The observations on days taken to first flower openingas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.10 and illustrated in Fig. 4.10.

The days taken to first flower openingwas significantly influenced by the spacing treatments. Day's taken to first flower openingfor spacing was varied from 57.56 to 58.89 days. The minimum days taken to first flower opening (57.56 days) was recorded with S_3 (30 x30 cm) followed by 57.67 days with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other and superior over S_1 (45 x 45 cm) which took maximum days to first flower opening(58.89 days).

The days taken to first flower openingwas significantly influenced by the pinching treatments. Days taken to first flower openingfor pinching were varied from 57.00 to 59.33. The minimum days taken to first flower opening(57.00 days) was recorded with P_0 (no pinching) followed by 57.78 days with P_1 (single pinching) and both of these treatments were statistically at par to each other and superior over P_2 (double pinching) which took maximum days to first flower opening(59.33 days).

The interaction effect between spacing and pinching (Table 4.10) were found to be non-significant. Days taken to first flower openingfor interaction were varied from 56.67 to 60.33 days. However, comparatively less time (56.67 days) was required in the treatment combination of spacing (30x30 cm) with no pinching (S_3P_0) and spacing (45x30 cm) with no pinching (S_2P_0) followed by S_2P_1 (57.00 days), S_3P_1 (57.67 days) and S_1P_0 (57.67 days) while more periods 60.33 days was taken in wider spacing of 45x45 cm with double pinching (S_1P_2) for first flower opening.

Table No. 4.10. Effect of different plant spacing and pinching on days taken to first flower opening

Treatment	days taken to first flower opening
Spacing (cm)	
45X45 (S_1)	58.89
45X30 (S_2)	57.67
30X30 (S_3)	57.56
SE (m) ±	**0.33**
CD at 5%	**0.98**
Pinching	
No pinching (P_0)	57.00
Single pinching (P_1)	57.78
Double pinching (P_2)	59.33
SE (m) ±	**0.33**
CD at 5%	**0.98**
Spacing x Pinching	
S_1P_0	57.67
S_1P_1	58.67
S_1P_2	60.33
S_2P_0	56.67
S_2P_1	57.00
S_2P_2	59.33
S_3P_0	56.67
S_3P_1	57.67
S_3P_2	58.33
SE (m) ±	**0.56**
CD at 5%	**NS**

Fig 4.10.1: Effect of spacing on days taken to first flower opening of marigold

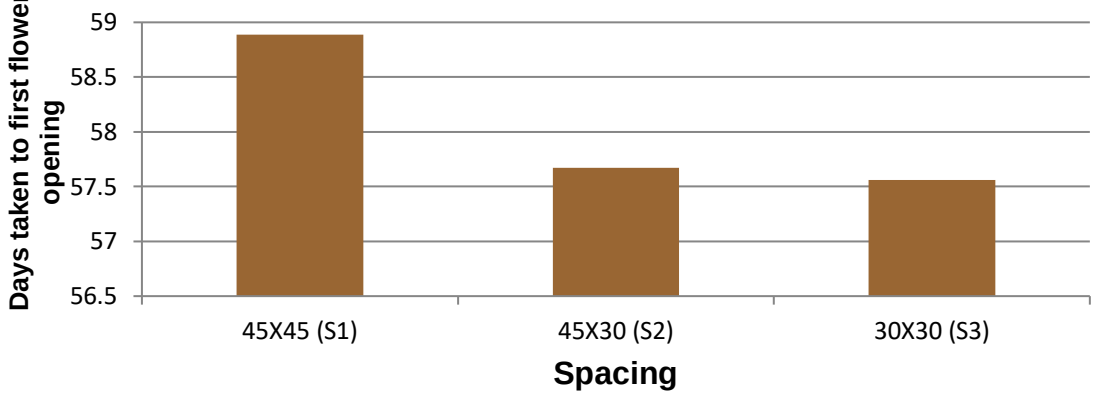


Fig 4.10.2: Effect of pinching on days taken to first flower opening of marigold

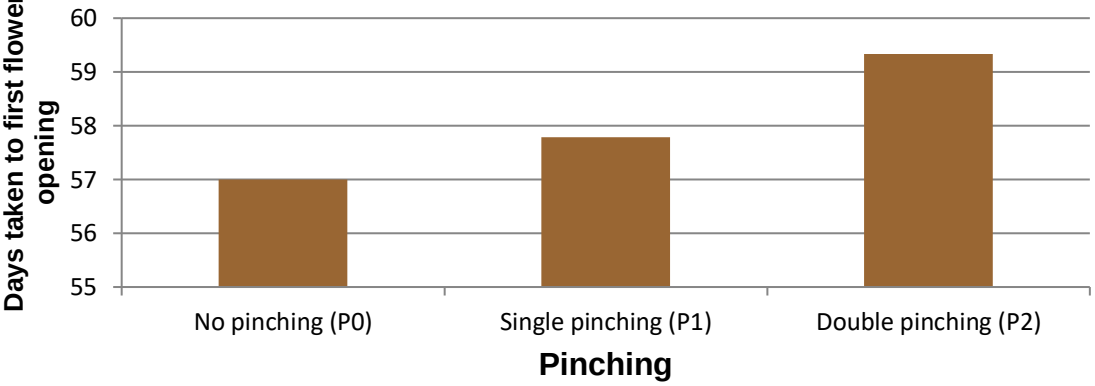
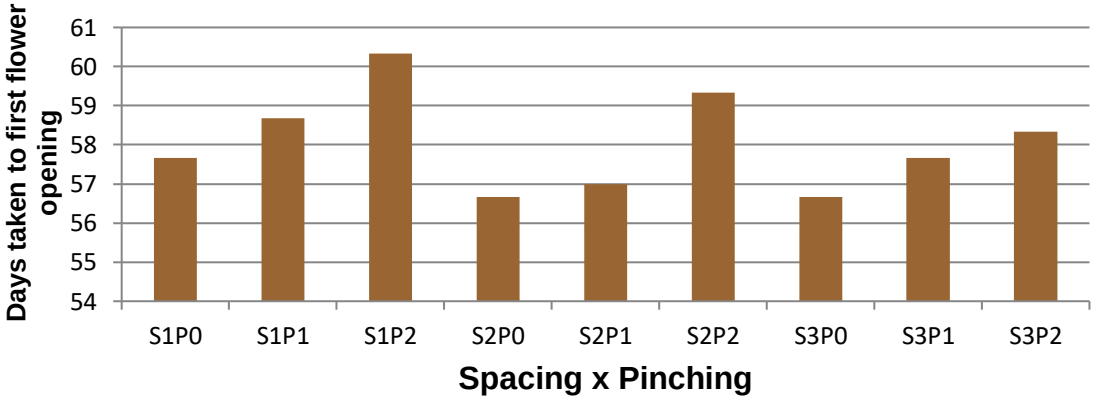


Fig 4.10.3: Effect of interaction on days taken to first flower opening of marigold



4.11 Days taken to 50% flowering

The observations on days taken to 50% flowering as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.11 and illustrated in Fig. 4.11.

The days taken to 50% flowering was significantly influenced by the spacing treatments. Day's taken to 50% flowering for spacing was varied from 63.33 to 64.44 days. The minimum days taken to 50% flowering (63.33 days) were recorded with S_3 (30 x30 cm) which was statistically superior over other treatments. Whereas the maximum days taken to 50% flowering (64.44 days) were recorded with S_1 (45 x 45 cm) followed by 64.22 days with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The days taken to 50% flowering was significantly influenced by the pinching treatments. Days taken to 50% flowering for pinching were varied from 63.44 to 64.56. The minimum days taken to 50% flowering (63.44 days) was recorded with P_0 (no pinching) followed by 64.00 days with P_1 (single pinching) and both of these treatments were statistically at par to each other. Whereas the maximum days taken to 50% flowering (64.56 days) were recorded with P_2 (double pinching).

The interaction effect between spacing and pinching (Table 4.11) were found to be non-significant. Days taken to 50% flowering for interaction were varied from 63 to 65 days. However, comparatively less time (63.00 days) was required in the treatment combination of spacing (30x30 cm) with no pinching (S_3P_0) and followed by S_3P_1 (63.33 days), S_2P_0 (63.33 days) and S_3P_2 (63.67 days) while more period(65 days) was taken in wider spacing of 45x30 cm with double pinching (S_2P_2) and spacing of 45x45 cm with double pinching (S_1P_2) for days taken to 50% flowering.

Table No. 4.11. Effect of different plant spacing and pinching on days taken to 50% flowering

Treatment	days taken to 50% flowering
Spacing (cm)	
45X45 (S_1)	64.44
45X30 (S_2)	64.22
30X30 (S_3)	63.33
SE (m) ±	**0.26**
CD at 5%	**0.78**
Pinching	
No pinching (P_0)	63.44
Single pinching (P_1)	64.00
Double pinching (P_2)	64.56
SE (m) ±	**0.26**
CD at 5%	**0.78**
Spacing x Pinching	
S_1P_0	64.00
S_1P_1	64.33
S_1P_2	65.00
S_2P_0	63.33
S_2P_1	64.33
S_2P_2	65.00
S_3P_0	63.00
S_3P_1	63.33
S_3P_2	63.67
SE (m) ±	**0.45**
CD at 5%	**NS**

Fig 4.11.1: Effect of spacing on days taken to 50% flowering of marigold

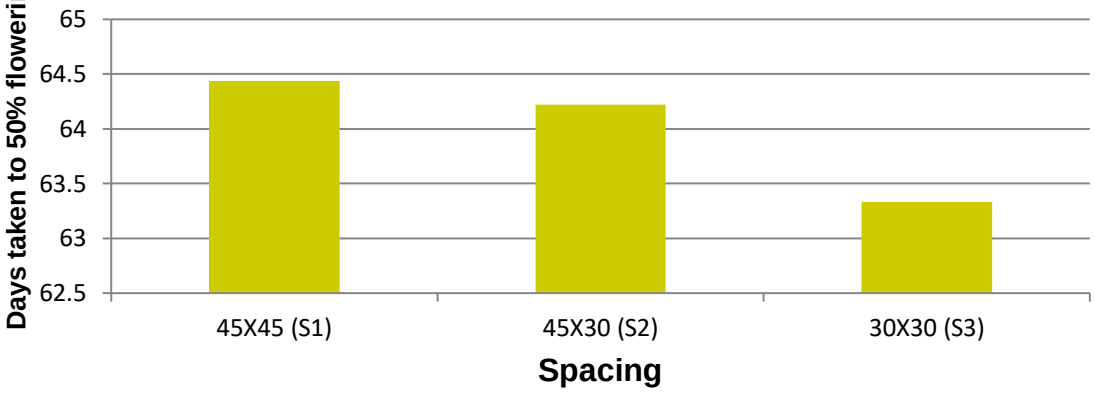


Fig 4.11.2: Effect of pinching on days taken to 50% flowering of marigold

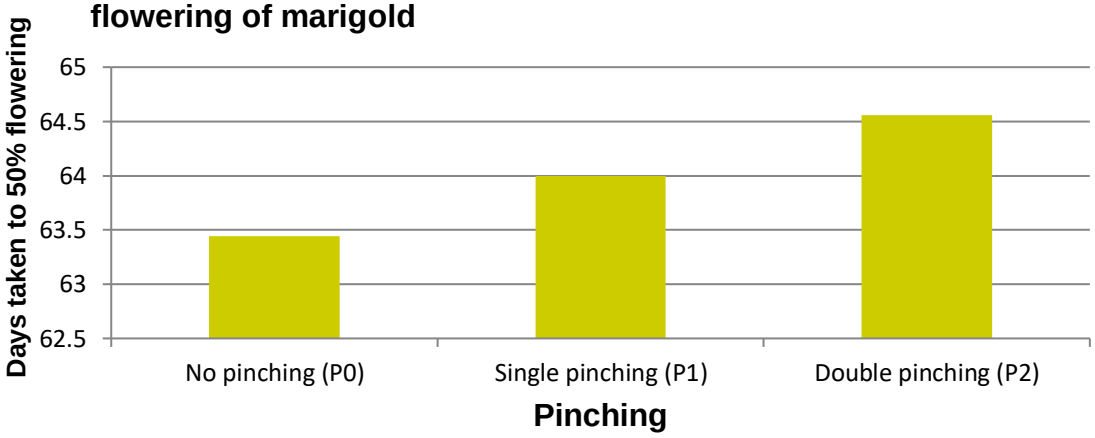
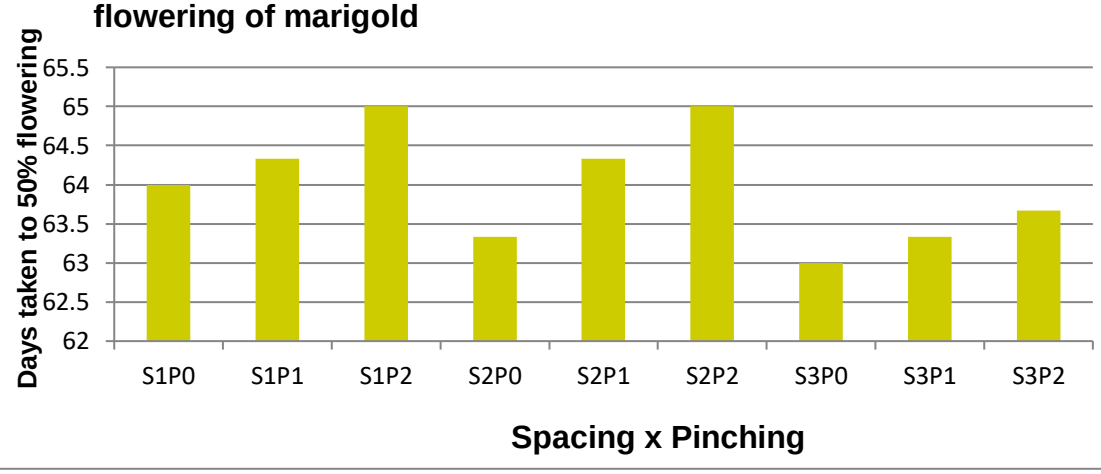


Fig 4.11.3: Effect of interaction on days taken to 50% flowering of marigold



4.12 Fresh weight of flower (g)

The observations on fresh weight of floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.12 and illustrated in Fig. 4.12.

The fresh weight of flowerwas significantly influenced by the spacing treatments. Fresh weight of flowerfor spacing was varied from 4.33 g to 4.70 g. The maximum fresh weight of flower(4.70 g) was recorded with S_1 (45 x 45 cm) followed by 4.46 g with S_2 (45 x 30 cm). Whereas the minimum fresh weight of flower(4.33 g) was recorded with S_3 (30 x 30 cm) and all of these treatments are statistically differ to each other.

Similarly, the fresh weight of flower was significantly influenced by the pinching treatments. Fresh weight of flowerfor pinching was varied from 4.26 g to 4.74 g. The maximum fresh weight of flower (4.74 g) was recorded with P_0 (no pinching) followed by 4.49 g with P_1 (single pinching). Whereas the minimum fresh weight of flower(4.26 g) was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.12) were found to be significant. Fresh weight of flowerfor interaction was varied from 4.19 g to 5.09 g. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum fresh weight of flower(5.09 g) which was followed by S_1P_1 (4.68 g), S_2P_0 (4.63 g) and S_3P_0 (4.49 g) and all of these treatment are statistically at par to each other except S_1P_0. Whereas, closer spacing (30x30 cm) with double pinching (S_3P_2) gave minimum fresh weight of flower(4.19 g) followed by S_2P_2 (4.26 g), S_3P_1 (4.32 g) and S_1P_2 (4.33 g) and all of these treatment are statistically at par to each other.

Table No. 4.12. Effect of different plant spacing and pinching on fresh weight of flower

Treatment	Fresh weight of flower (g)
Spacing (cm)	
45X45 (S_1)	4.70
45X30 (S_2)	4.46
30X30 (S_3)	4.33
SE (m) ±	**0.04**
CD at 5%	**0.12**
Pinching	
No pinching (P_0)	4.74
Single pinching (P_1)	4.49
Double pinching (P_2)	4.26
SE (m) ±	**0.04**
CD at 5%	**0.12**
Spacing x Pinching	
S_1P_0	5.09
S_1P_1	4.68
S_1P_2	4.33
S_2P_0	4.63
S_2P_1	4.48
S_2P_2	4.26
S_3P_0	4.49
S_3P_1	4.32
S_3P_2	4.19
SE (m) ±	**0.07**
CD at 5%	**0.214**

Fig 4.12.1: Effect of spacing on fresh weight of flower (g) of marigold

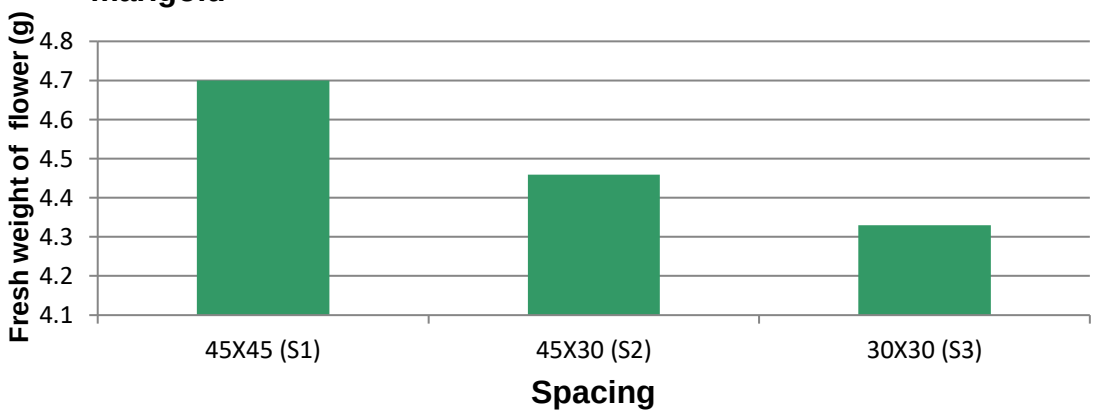


Fig 4.12.2: Effect of pinching on fresh weight of flower (g) of marigold

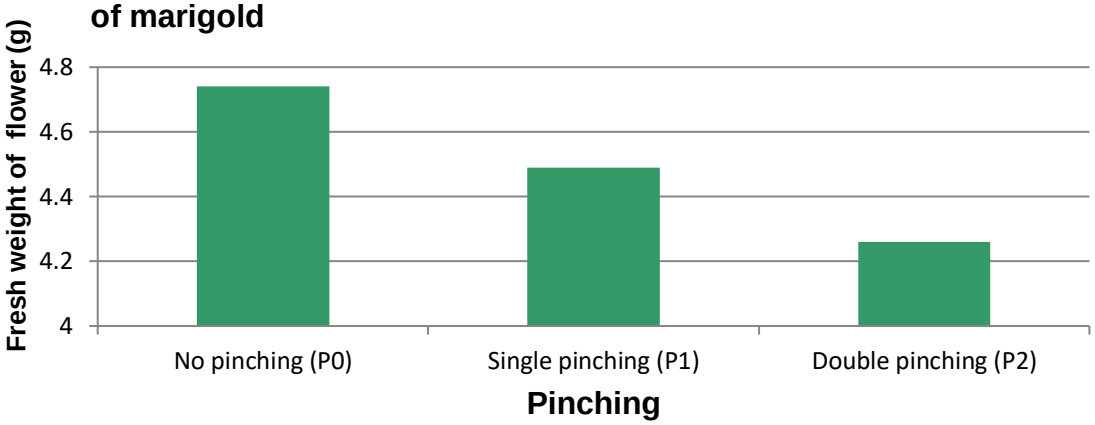
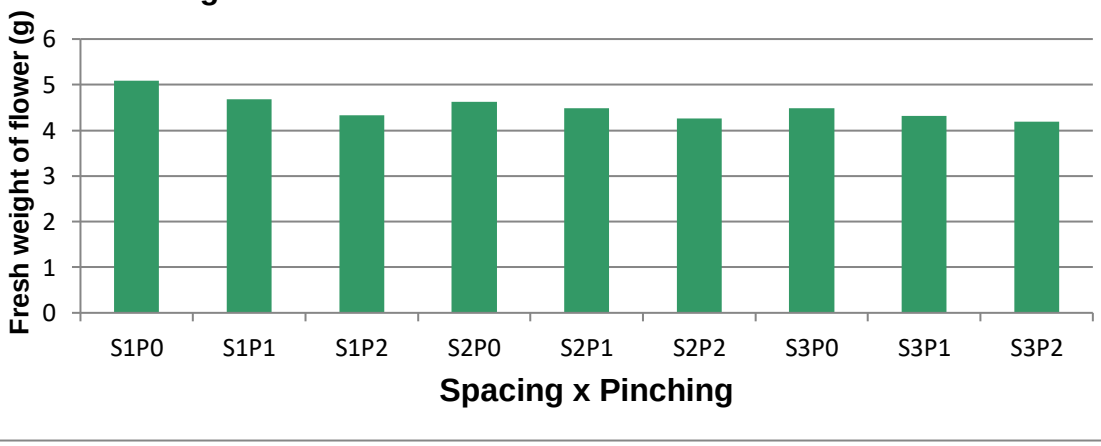


Fig 4.12.3: Effect of interaction on fresh weight of flower (g) of marigold



4.13 Dry weight of flower (g)

The observations on dry weight of floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.13 and illustrated in Fig. 4.13.

The dry weight of flowerwas significantly influenced by the spacing treatments. Dry weight of flowerfor spacing was varied from 0.59 g to 0.64 g. The maximum dry weight of flower(0.64 g) was recorded with S_1 (45 x 45 cm) followed by 0.61 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum dry weight of flower0.59 g was recorded with S_3 (30 x 30 cm).

Similarly, the dry weight of flower was significantly influenced by the pinching treatments. Dry weight of flowerfor pinching was varied from 0.58 g to 0.65 g. The maximum dry weight of flower (0.65 g) was recorded with P_0 (no pinching) which was statistically superior over other treatments. Whereas the minimum dry weight of flower (0.58 g) was recorded with P_2 (double pinching) followed by 0.61 g with P_1 (single pinching) and both of these treatment are statistically at par to each other.

The interaction effect between spacing and pinching (Table 4.13) were found to be non-significant. Dry weight of flowerfor interaction was varied from 0.56 g to 0.68 g. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum dry weight of flower(0.68 g) which was followed by S_2P_0 (0.65 g), S_1P_1 (0.64 g) and S_3P_0 (0.63 g). Whereas, closer spacing (30x30 cm) with double pinching (S_3P_2) gave minimum dry weight of flower(0.56 g).

Table No. 4.13. Effect of different plant spacing and pinching on dry weight of flower

Treatment	Dry weight of flower (g)
Spacing (cm)	
45X45 (S_1)	0.64
45X30 (S_2)	0.61
30X30 (S_3)	0.59
SE (m) ±	**0.01**
CD at 5%	**0.03**
Pinching	
No pinching (P_0)	0.65
Single pinching (P_1)	0.61
Double pinching (P_2)	0.58
SE (m) ±	**0.01**
CD at 5%	**0.03**
Spacing x Pinching	
S_1P_0	0.68
S_1P_1	0.64
S_1P_2	0.62
S_2P_0	0.65
S_2P_1	0.61
S_2P_2	0.57
S_3P_0	0.63
S_3P_1	0.59
S_3P_2	0.56
SE (m) ±	**0.02**
CD at 5%	**NS**

Fig 4.13.1: Effect of spacing on dry weight of flower (g) of marigold

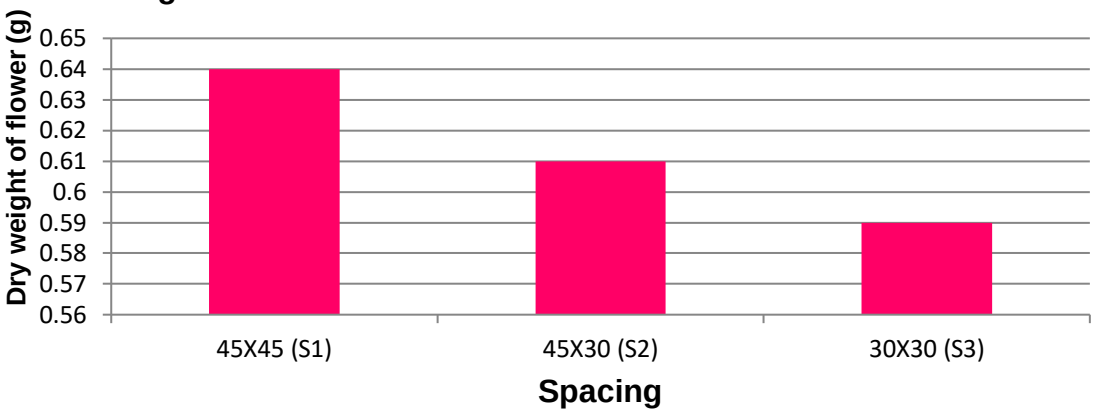


Fig 4.13.2: Effect of pinching on dry weight of flower (g) of marigold

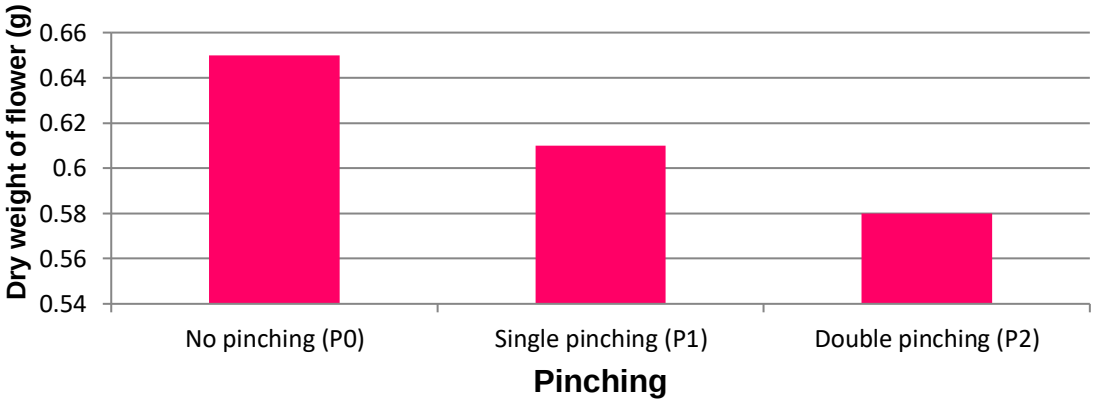
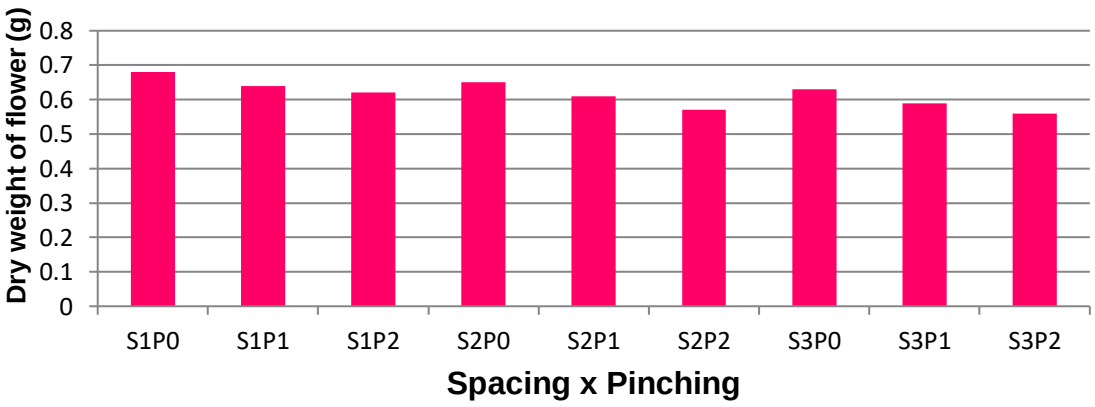


Fig 4.13.3: Effect of interaction on dry weight of flower (g) of marigold



4.14 Flower diameter (cm)

The observation on flower diameter as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.14 and illustrated in Fig. 4.14.

The flower diameterwas significantly influenced by the spacing treatments. Flower diameterfor spacing was varied from 4.29 cm to 4.50 cm. The maximum flower diameter(4.50 cm) was recorded with S_1 (45 x 45 cm) and it was statistically differ to other treatments. Whereas the minimum flower diameter**(**4.29 cm) was recorded with S_3 (30 x 30 cm) followed by 4.36 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The flower diameterwas significantly influenced by the pinching treatments. Flower diameterfor pinching was varied from 4.04 cm to 4.70 cm. The maximum flower diameter(4.70 cm) was recorded with P_0 (no pinching) followed by 4.41 cm with P_1 (single pinching). Whereas the minimum flower diameter(4.04 cm) was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.14) were found to be non-significant. Flower diameterfor interaction was varied from 3.97 cm to 4.81 cm. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum flower diameter(4.81 cm) which was followed by S_2P_0 (4.67 cm), S_3P_0 (4.63 cm) and S_1P_1 (4.57 cm). Whereas, closer spacing (30x30 cm) with double pinching (S_3P_2) gave minimum flower diameter(3.97 cm).

Table No. 4.14. Effect of different plant spacing and pinching on flower diameter (cm)

Treatment	Flower diameter (cm)
Spacing (cm)	
45X45 (S_1)	4.50
45X30 (S_2)	4.36
30X30 (S_3)	4.29
SE (m) ±	**0.04**
CD at 5%	**0.13**
Pinching	
No pinching (P_0)	4.70
Single pinching (P_1)	4.41
Double pinching (P_2)	4.04
SE (m) ±	**0.04**
CD at 5%	**0.13**
Spacing x Pinching	
S_1P_0	4.81
S_1P_1	4.57
S_1P_2	4.13
S_2P_0	4.67
S_2P_1	4.39
S_2P_2	4.01
S_3P_0	4.63
S_3P_1	4.27
S_3P_2	3.97
SE (m) ±	**0.08**
CD at 5%	**NS**

Fig 4.14.1: Effect of spacing on flower diameter (cm) of marigold

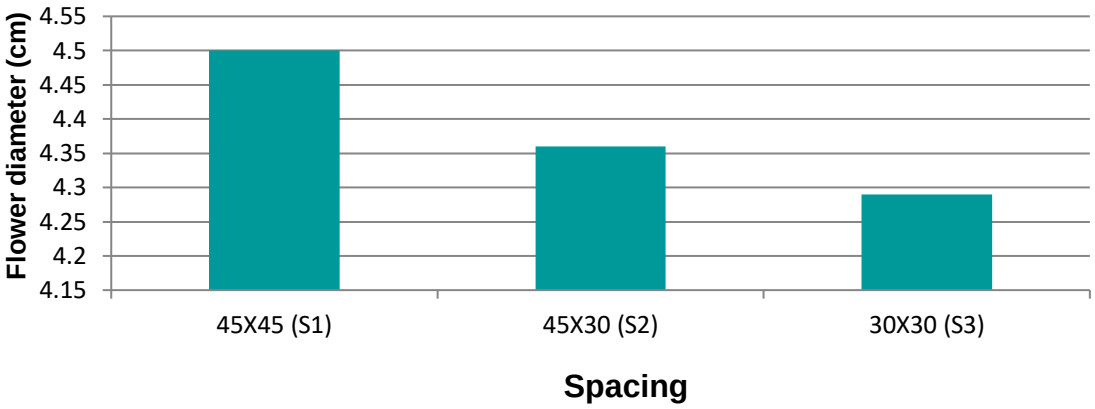


Fig 4.14.2: Effect of pinching on flower diameter (cm) of marigold

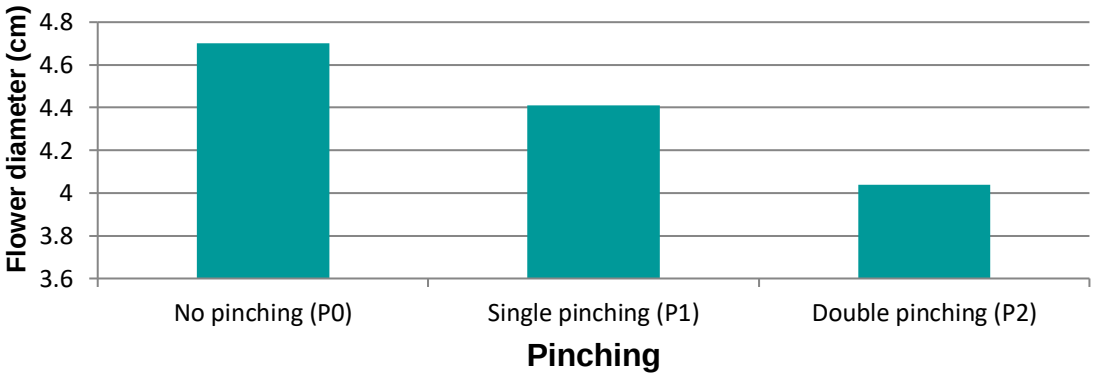
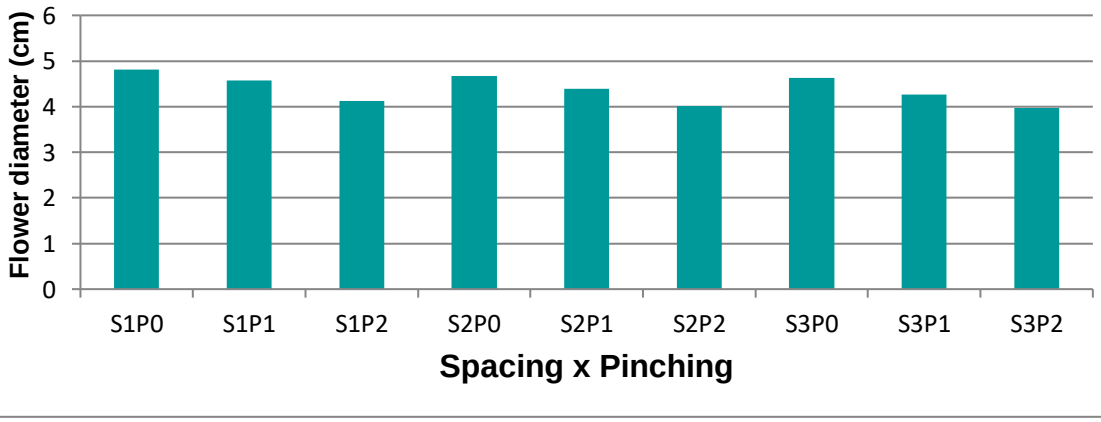


Fig 4.14.3: Effect of interaction on flower diameter (cm) of marigold



4.15 Duration of flowering

The observation on duration of flowering as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.15 and illustrated in Fig. 4.15.

The duration of flowering was significantly influenced by the spacing treatments. Duration of flowering for spacing was varied from 67.89 to 84.33 days. The maximum duration of flowering (84.33 days) was recorded with S_1 (45 x 45 cm) and it was statistically superior over other treatments. Whereas the minimum duration of flowering (67.89 days) were recorded with S_3 (30 x 30 cm) followed by 70.44 days with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The duration of flowering was significantly influenced by the pinching treatments. Duration of flowering for pinching was varied from 69.00 to 79.33 days. The maximum duration of flowering (79.33 days) was recorded with P_2 (double pinching) followed by 74.33 days with P_1 (single pinching). Whereas the minimum duration of flowering (69.00) days were recorded with P_0 (no pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.15) were found to be significant. Duration of flowering for interaction was varied from 64.00 to 94.67 days. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum duration of flowering (94.67 days) which was followed by S_1P_1 (83.33 days) and both of these treatments are statistically superior over other treatments. Whereas, closer spacing (30x30 cm) with no pinching (S_3P_0) gave minimum duration of flowering (64 days) followed by S_2P_0 (68.00 days) and S_3P_1 (69 days) and they are statistically at par to each other.

Table No. 4.15. Effect of different plant spacing and pinching on duration of flowering

Treatment	Duration of flowering
Spacing (cm)	
45X45 (S_1)	84.33
45X30 (S_2)	70.44
30X30 (S_3)	67.89
SE (m) ±	**1.25**
CD at 5%	**3.76**
Pinching	
No pinching (P_0)	69.00
Single pinching (P_1)	74.33
Double pinching (P_2)	79.33
SE (m) ±	**1.25**
CD at 5%	**3.76**
Spacing x Pinching	
S_1P_0	75.00
S_1P_1	83.33
S_1P_2	94.67
S_2P_0	68.00
S_2P_1	70.67
S_2P_2	72.67
S_3P_0	64.00
S_3P_1	69.00
S_3P_2	70.67
SE (m) ±	**2.17**
CD at 5%	**6.515**

Fig 4.15.1: Effect of spacing on duration of flowering of marigold

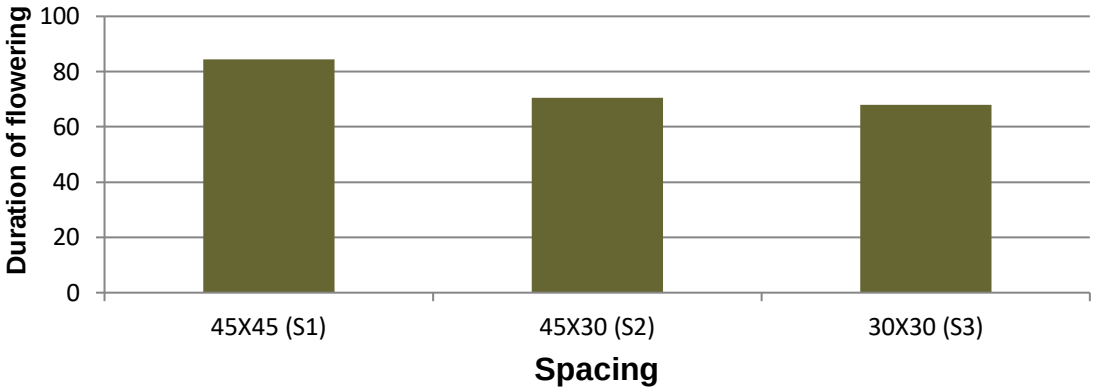


Fig 4.15.2: Effect of pinching on duration of flowering of marigold

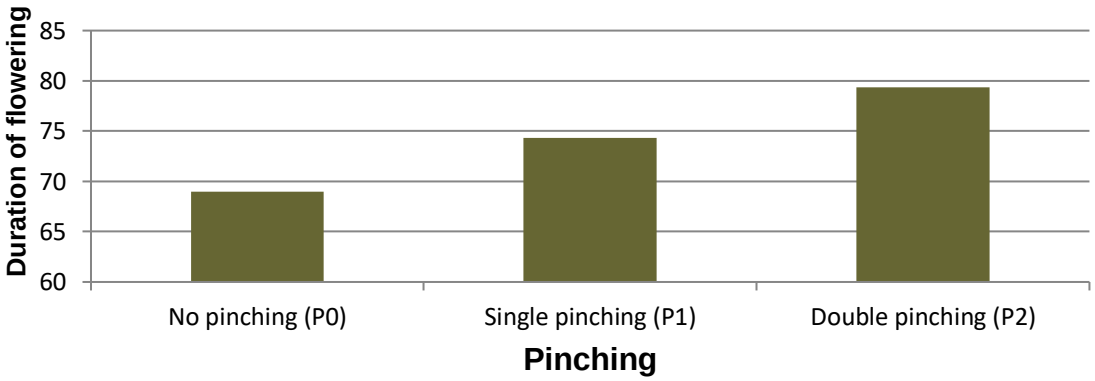
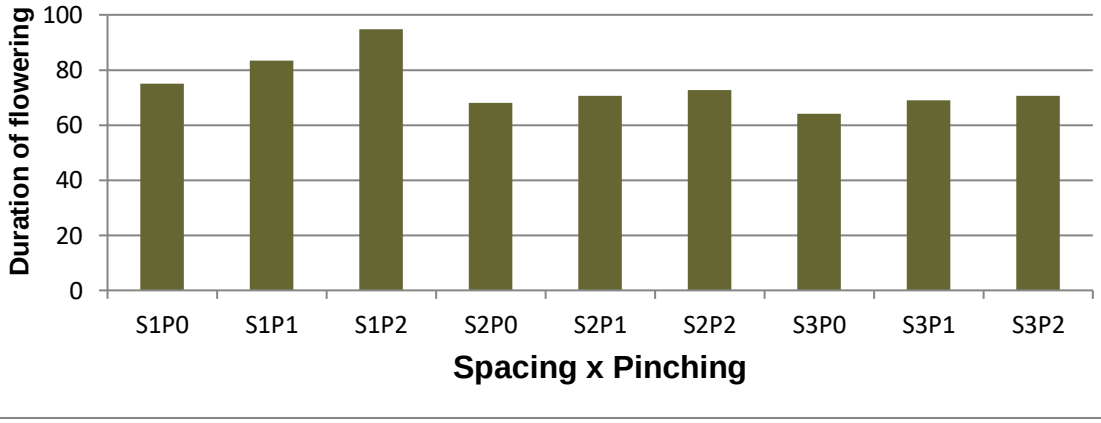


Fig 4.15.3: Effect of interaction on duration of flowering of marigold



4.16 Chlorophyll content in leaves (SPAD value)

The observations on chlorophyll content in leavesas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.16 and illustrated in Fig. 4.16.

The chlorophyll content in leaveswas significantly influenced by the spacing treatments. Chlorophyll content in leavesfor spacing was varied from 29.70 to 40.51. The maximum chlorophyll content in leaves(40.51) was recorded with S_3 (30 x 30 cm) and it was statistically superior over other treatments. Whereas the minimum chlorophyll content in leaves(29.70) were recorded with S_1 (45 x 45 cm) followed by 31.88 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

Similarly, the chlorophyll content in leaveswas significantly influenced by the pinching treatments. Chlorophyll content in leavesfor pinching was varied from 29.20 to 39.15. The maximum chlorophyll content in leaves(39.15) was recorded with P_2 (double pinching) and it was statistically superior over other treatments. Whereas the minimum chlorophyll content in leaves(29.20) were recorded with P_0 (no pinching) followed by 33.75 with P_1 (single pinching) and both of these treatment are statistically at par to each other.

The interaction effect between spacing and pinching (Table 4.16) were found to be non-significant. Chlorophyll content in leavesfor interaction was varied from 26.34 to 46.62. The spacing of 30x30 cm with double pinching (S_3P_2) gave maximum chlorophyll content in leaves(46.62) which was followed by S_3P_1 (40.82), S_2P_2 (36.56) and S_1P_2 (34.27). Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum chlorophyll content in leaves(26.34).

Table No. 4.16. Effect of different plant spacing and pinching on chlorophyll content in leaves (SPAD value)

Treatment	Chlorophyll content in leaves (SPAD value)
Spacing (cm)	
45X45 (S_1)	29.70
45X30 (S_2)	31.88
30X30 (S_3)	40.51
SE (m) ±	**1.56**
CD at 5%	**4.67**
Pinching	
No pinching (P_0)	29.20
Single pinching (P_1)	33.75
Double pinching (P_2)	39.15
SE (m) ±	**1.56**
CD at 5%	**4.67**
Spacing x Pinching	
S_1P_0	26.34
S_1P_1	28.51
S_1P_2	34.27
S_2P_0	27.17
S_2P_1	31.92
S_2P_2	36.56
S_3P_0	34.10
S_3P_1	40.82
S_3P_2	46.62
SE (m) ±	**2.70**
CD at 5%	**NS**

Fig 4.16.1: Effect of spacing on chlorophyll content in leaves (SPAD value) of marigold

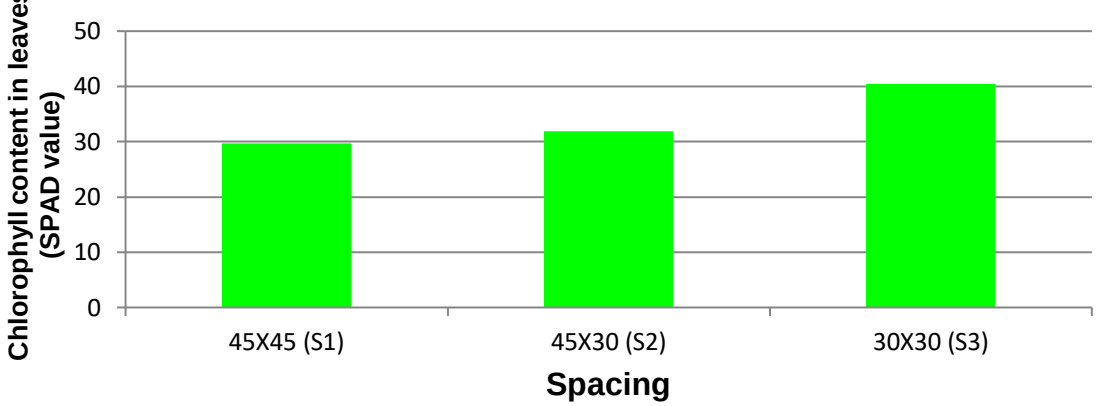


Fig 4.16.2: Effect of pinching on chlorophyll content in leaves (SPAD value) of marigold

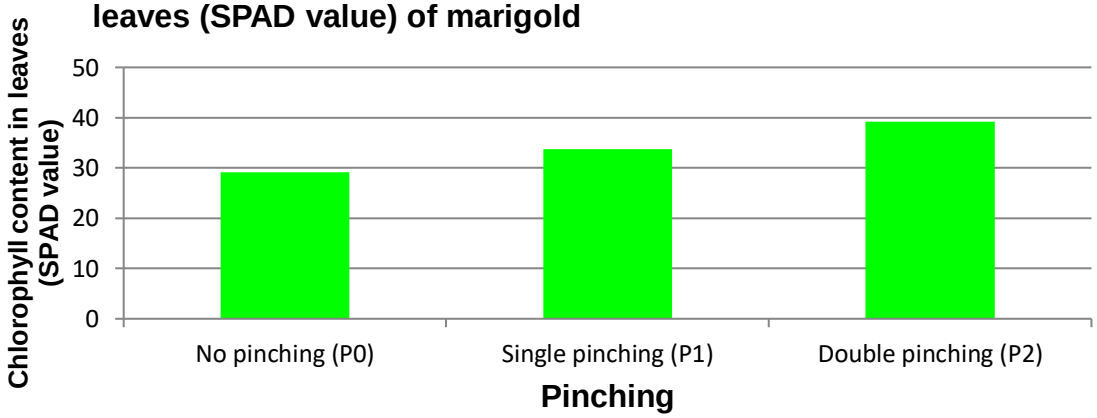
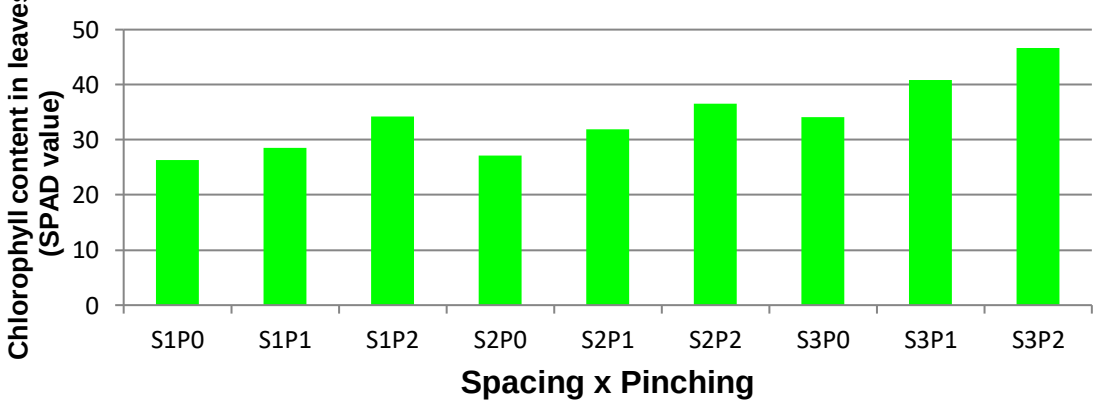


Fig 4.16.3: Effect of interaction on chlorophyll content in leaves (SPAD value) of marigold



4.17 Carotenoid's in petals (mg/g)

The observations on carotenoid's in petalsas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.17 and illustrated in Fig. 4.17.

The carotenoid's in petalswas significantly influenced by the spacing treatments. Carotenoid's in petalsfor spacing was varied from 16.03 to 21.51 mg/g. The maximum carotenoid's in petals (21.51 mg/g) was recorded with S_3 (30 x 30 cm) and it was statistically superior over other treatments. Whereas the minimum carotenoid's in petals(16.03 mg/g) were recorded with S_1 (45 x 45 cm) followed by 17.28 mg/g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The carotenoid's in petalswas significantly influenced by the pinching treatments. Carotenoid's in petalsfor pinching was varied from 16.82 mg/g to 19.67 mg/g. The maximum carotenoid's in petals(19.67 mg/g) was recorded with P_2 (double pinching) followed by 18.33 mg/g with P_1 (single pinching) and both of these treatment are statistically at par to each other and superior over P_0 (16.82 mg/g).

The interaction effect between spacing and pinching (Table 4.17) were found to be non-significant. Carotenoid's in petalsfor interaction was varied from 14 to 22.80 mg/g. The spacing of 30x30 cm with double pinching (S_3P_2) gave maximum carotenoid's in petals(22.80 mg/g) which was followed by S_3P_1 (21.87 mg/g), S_3P_0 (19.87 mg/g) and S_2P_2 (18.40 mg/g). Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum carotenoid's in petals(14 mg/g).

Table No. 4.17. Effect of different plant spacing and pinching on carotenoids in petals (mg/g)

Treatment	carotenoids in petals (mg/g)
Spacing (cm)	
45X45 (S_1)	16.03
45X30 (S_2)	17.28
30X30 (S_3)	21.51
SE (m) ±	**0.45**
CD at 5%	**1.36**
Pinching	
No pinching (P_0)	16.82
Single pinching (P_1)	18.33
Double pinching (P_2)	19.67
SE (m) ±	**0.45**
CD at 5%	**1.36**
Spacing x Pinching	
S_1P_0	14.00
S_1P_1	16.29
S_1P_2	17.80
S_2P_0	16.60
S_2P_1	16.83
S_2P_2	18.40
S_3P_0	19.87
S_3P_1	21.87
S_3P_2	22.80
SE (m) ±	**0.79**
CD at 5%	**NS**

Fig 4.17.1: Effect of spacing on carotenoids in petals (mg/g) of marigold

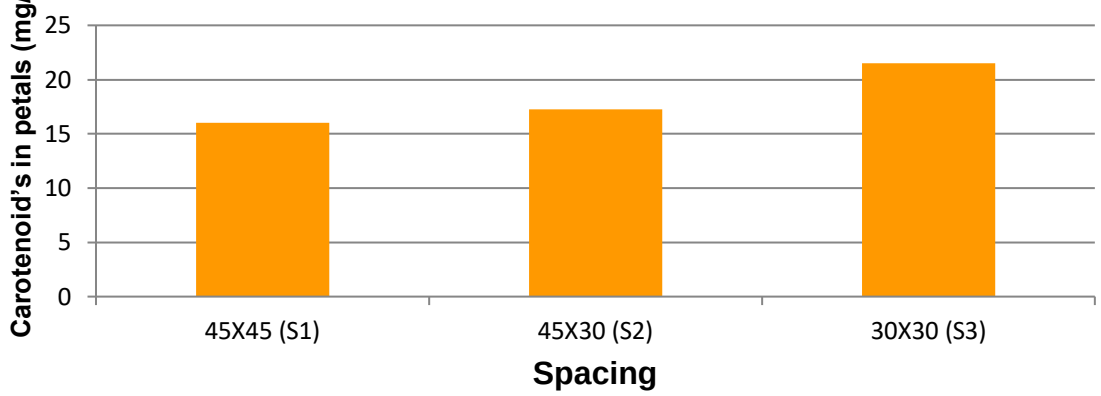


Fig 4.17.2: Effect of pinching on carotenoids in petals (mg/g) of marigold

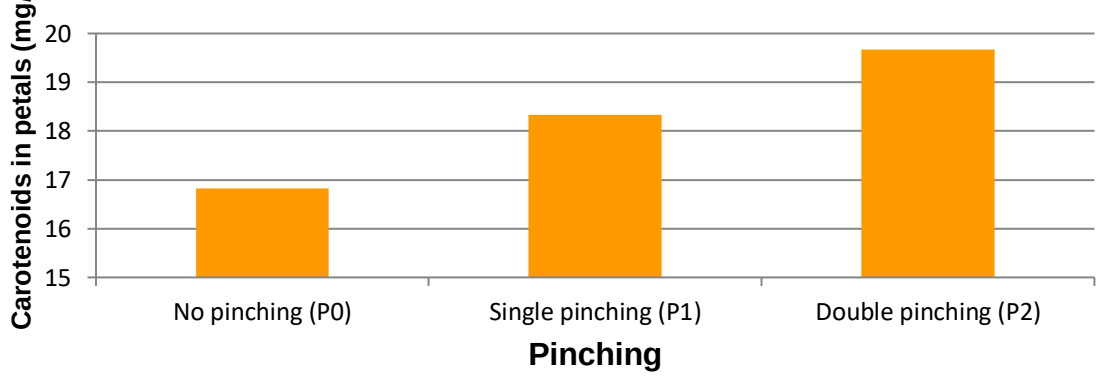
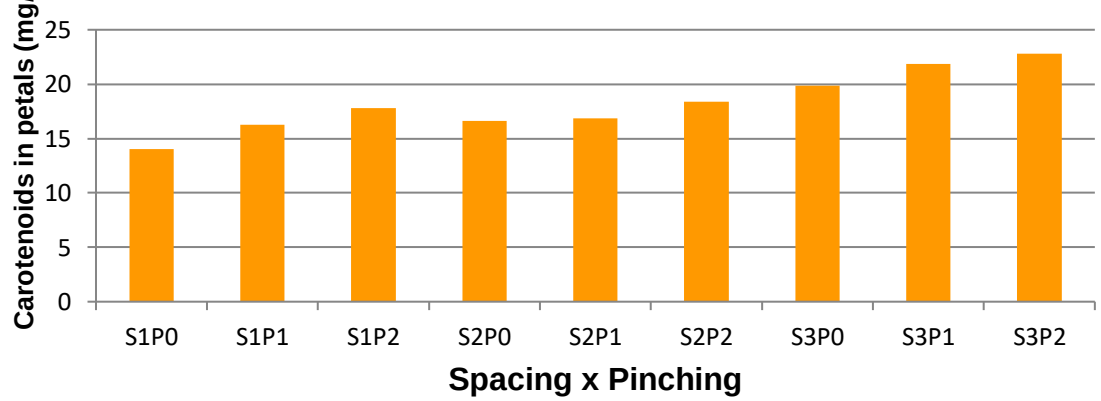


Fig 4.17.3: Effect of interaction on carotenoids in petals (mg/g) of marigold



4.18 Flower yield per plant (g)

The observations on flower yield per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.18 and illustrated in Fig. 4.18.

The flower yield per plantwas significantly influenced by the spacing treatments. Flower yield per plantfor spacing was varied from 108.33 g to 180.22 g. The maximum flower yield per plant(180.22 g) was recorded with S_1 (45 x 45 cm) and it was statistically superior to other treatments. Whereas the minimum flower yield per plant(108.33 g) was recorded with S_3 (30 x 30 cm) followed by 128.67 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The flower yield per plantwas significantly influenced by the pinching treatments. Flower yield per plantfor pinching was varied from 98.78 g to 163.67 g. The maximum flower yield per plant(163.67 g) was recorded with P_2 (double pinching) followed by 154.78 g with P_1 (single pinching) and both of these treatment are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per plant (98.78 g).

The interaction effect between spacing and pinching (Table 4.18) were found to be significant. Flower yield per plantfor interaction was varied from 90 g to 218.33 g. The spacing of 45 x 45 cm with double pinching (S_1P_2) gave maximum flower yield per plant(218.33 g) which was followed by S_1P_1 (211.00 g) and both of these treatment are statistically at par to each other and superior over rest of the treatments. Whereas, spacing (30 x 30 cm) with no pinching (S_3P_0) gave minimum flower yield per plant(90.00 g) which was followed by S_2P_0 (95.00 g), S_3P_1 (108.33 g), S_1P_0 (111.33 g) and S_3P_2 (126.67 g). All of these are statistically at par to each other.

Table No. 4.18. Effect of different plant spacing and pinching on flower yield per plant (g)

Treatment	Flower yield per plant (g)
Spacing (cm)	
45X45 (S_1)	180.22
45X30 (S_2)	128.67
30X30 (S_3)	108.33
SE (m) ±	**7.61**
CD at 5%	**22.81**
Pinching	
No pinching (P_0)	98.78
Single pinching (P_1)	154.78
Double pinching (P_2)	163.67
SE (m) ±	**7.61**
CD at 5%	**22.81**
Spacing x Pinching	
S_1P_0	111.33
S_1P_1	211.00
S_1P_2	218.33
S_2P_0	95.00
S_2P_1	145.00
S_2P_2	146.00
S_3P_0	90.00
S_3P_1	108.33
S_3P_2	126.67
SE (m) ±	**13.18**
CD at 5%	**39.503**

Fig 4.18.1: Effect of spacing on flower yield per plant (g) of marigold

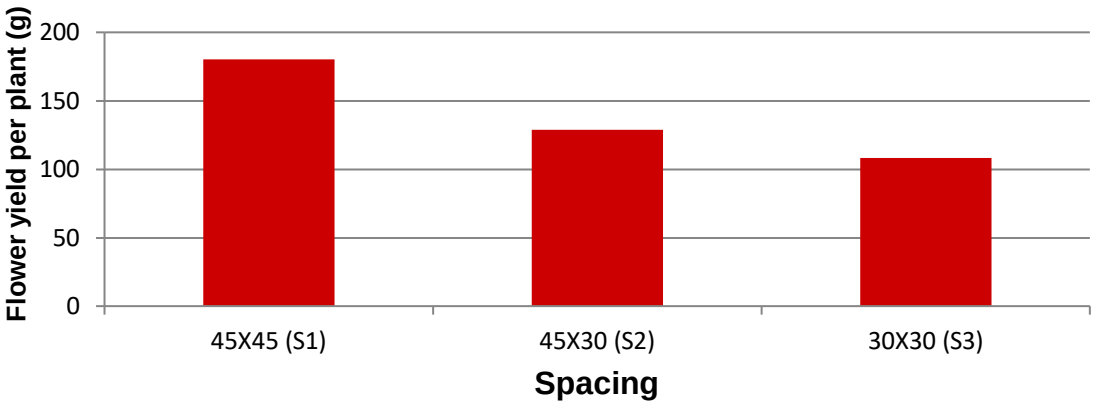


Fig 4.18.2: Effect of pinching on flower yield per plant (g) of marigold

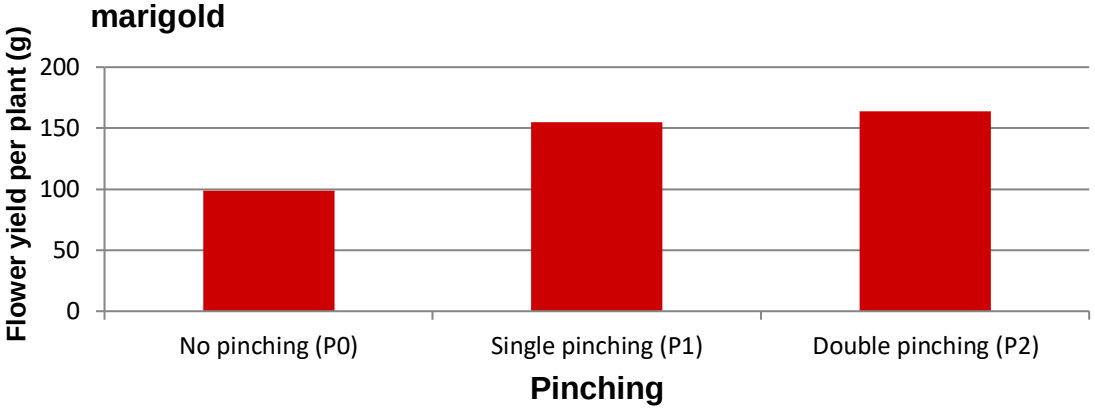
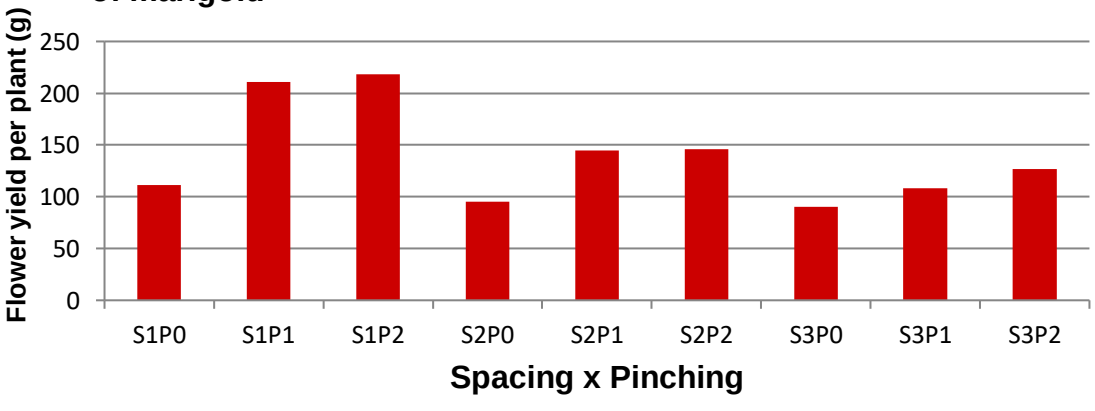


Fig 4.18.3: Effect of interaction on flower yield per plant (g) of marigold



4.19 Flower yield per plot (kg)

The observation on flower yield per plot as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.19 and illustrated in Fig. 4.19.

The flower yield per plot was significantly influenced by the spacing treatments. Flower yield per plotfor spacing was varied from 3.30 kg to 4.63 kg. The maximum flower yield per plot (4.63 kg) was recorded with S_3 (30 x 30 cm) followed by 3.62 kg with S_2 (45 x 30 cm). Whereas the minimum flower yield per plot (3.30 kg) was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

The flower yield per plotwas significantly influenced by the pinching treatments. Flower yield per plotfor pinching was varied from 3.09 kg to 4.32 kg. The maximum flower yield per plot(4.32 kg) was recorded with P_2 (double pinching) followed by 4.14 kg with P_1 (single pinching) and both of these treatments are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per plot (3.09 kg).

The interaction effect between spacing and pinching (Table 4.19) were found to be significant. Flower yield per plotfor interaction was varied from 2.27 kg to 5.13 kg. The spacing of 30 x 30 cm with double pinching (S_3P_2) gave maximum flower yield per plot(5.13 kg) which was followed by S_3P_1 (4.60 kg) and both of these treatments are statistically superior over rest of the treatments. Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum flower yield per plot(2.27 kg) followed by S_2P_0 (2.85 kg), S_1P_1 (3.73 kg) and S_1P_2 (3.90 kg).

Table No. 4.19. Effect of different plant spacing and pinching on flower yield per plot (kg)

Treatment	Flower yield per plot (kg)
Spacing (cm)	
45X45 (S_1)	3.30
45X30 (S_2)	3.62
30X30 (S_3)	4.63
SE (m) ±	**0.09**
CD at 5%	**0.26**
Pinching	
No pinching (P_0)	3.09
Single pinching (P_1)	4.14
Double pinching (P_2)	4.32
SE (m) ±	**0.09**
CD at 5%	**0.26**
Spacing x Pinching	
S_1P_0	2.27
S_1P_1	3.73
S_1P_2	3.90
S_2P_0	2.85
S_2P_1	4.10
S_2P_2	3.92
S_3P_0	4.15
S_3P_1	4.60
S_3P_2	5.13
SE (m) ±	**0.15**
CD at 5%	**0.445**

Fig 4.19.1: Effect of spacing on flower yield per plot (kg) of marigold

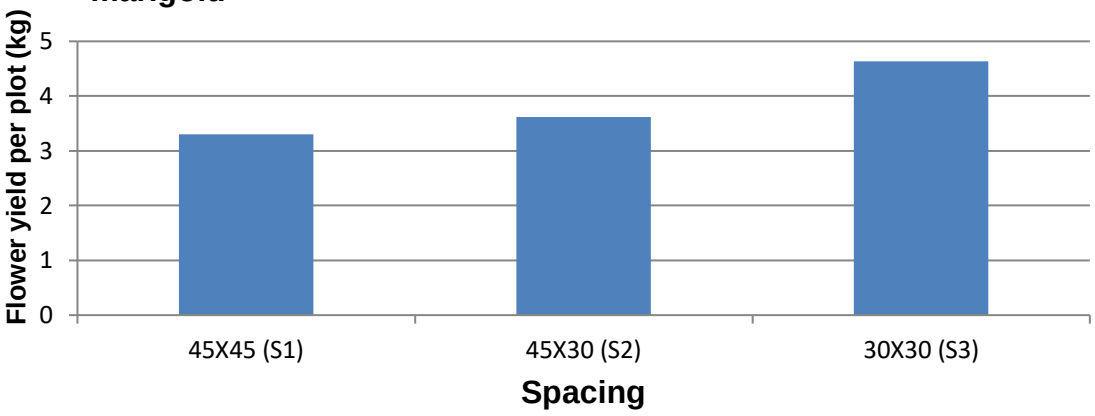


Fig 4.19.2: Effect of pinching on flower yield per plot (kg) of marigold

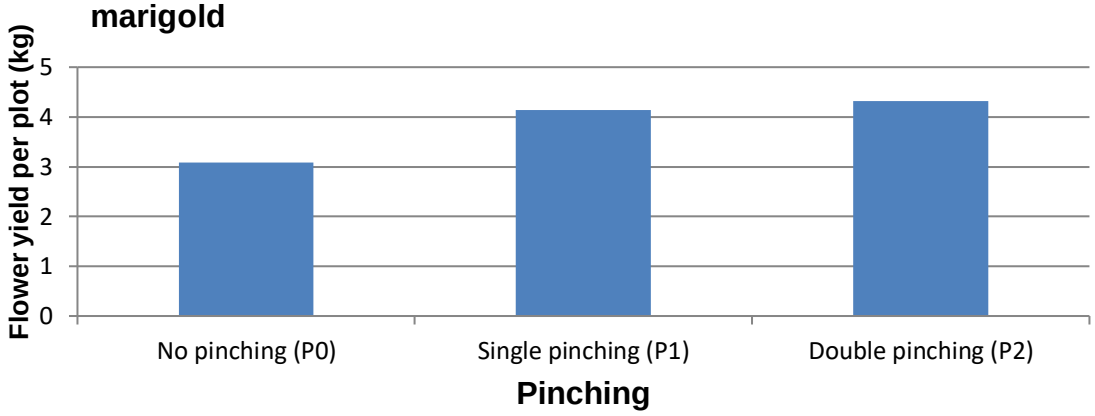
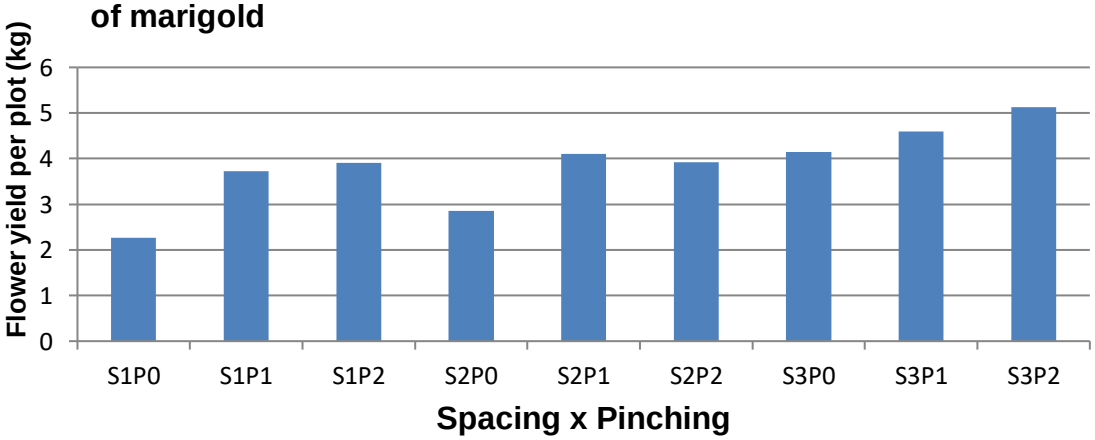


Fig 4.19.3: Effect of interaction on flower yield per plot (kg) of marigold



4.20 Flower yield per ha (q)

The observations on flower yield per ha as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.20 and illustrated in Fig. 4.20.

The flower yield per ha was significantly influenced by the spacing treatments. Flower yield per hafor spacing was varied from 101.84 q to 142.62 q. The maximum flower yield per ha (142.62 q) was recorded with S_3 (30 x 30 cm) followed by 112.09 q with S_2 (45 x 30 cm). Whereas the minimum flower yield per ha 101.84 q was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

Similarly, the flower yield per hawas significantly influenced by the pinching treatments. Flower yield per hafor pinching was varied from 95.34 q to 133.46 q. The maximum flower yield per ha(133.46 q) was recorded with P_2 (double pinching) followed by 127.75 q with P_1 (single pinching) and both of these treatment are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per ha (95.34 q).

The interaction effect between spacing and pinching (Table 4.20) were found to be significant. Flower yield per hafor interaction was varied from 69.95 to 158.13 q. The maximum flower yield per ha (158.13 q) was recorded with S_3P_2 and it was statistically superior over rest of the treatments which was followed by S_3P_1 (141.67 q), S_3P_0 (128.07 q) and S_2P_1 (126.36 q). Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum flower yield per ha(69.95 q).

Table No. 4.20. Effect of different plant spacing and pinching on flower yield per ha. (q)

Treatment	Flower yield per ha (q)
Spacing (cm)	
45X45 (S_1)	101.84
45X30 (S_2)	112.09
30X30 (S_3)	142.62
SE (m) ±	**3.05**
CD at 5%	**9.13**
Pinching	
No pinching (P_0)	95.34
Single pinching (P_1)	127.75
Double pinching (P_2)	133.46
SE (m) ±	**3.05**
CD at 5%	**9.13**
Spacing x Pinching	
S_1P_0	69.95
S_1P_1	115.22
S_1P_2	120.33
S_2P_0	88.00
S_2P_1	126.36
S_2P_2	121.91
S_3P_0	128.07
S_3P_1	141.67
S_3P_2	158.13
SE (m) ±	**5.28**
CD at 5%	**15.816**

Fig 4.20.1: Effect of spacing on flower yield per ha (q) of marigold

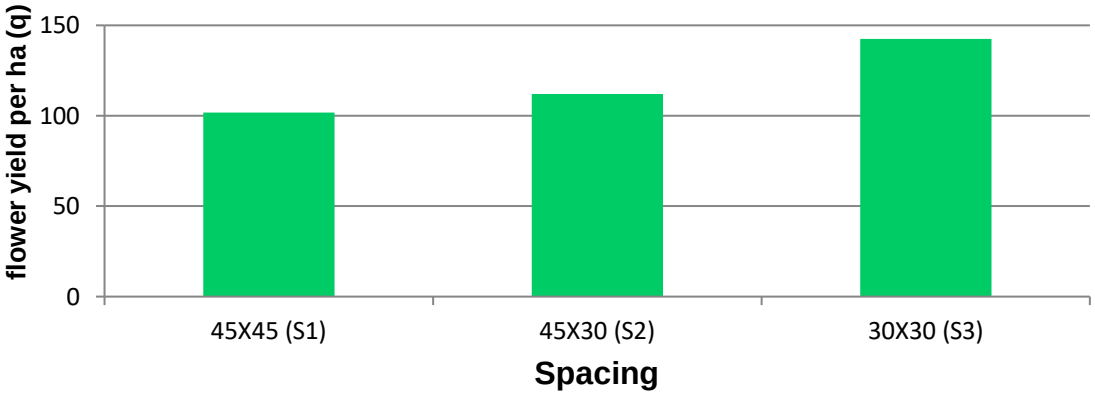


Fig 4.20.2: Effect of pinching on flower yield per ha (q) of marigold

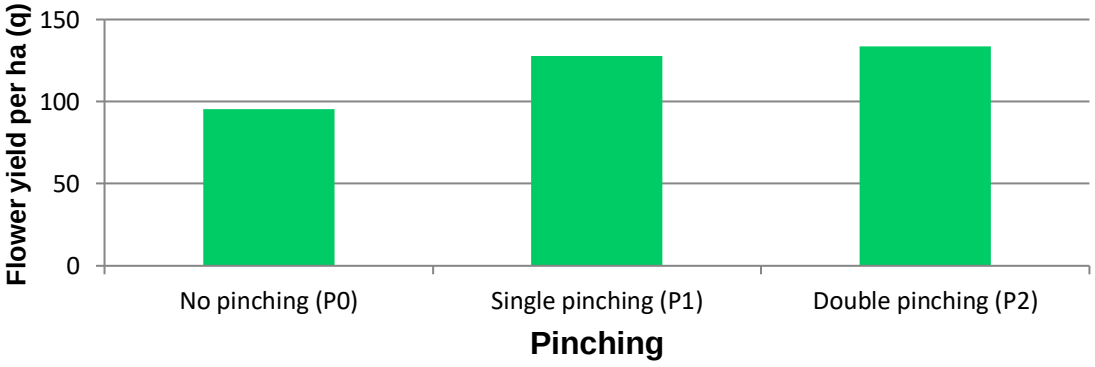
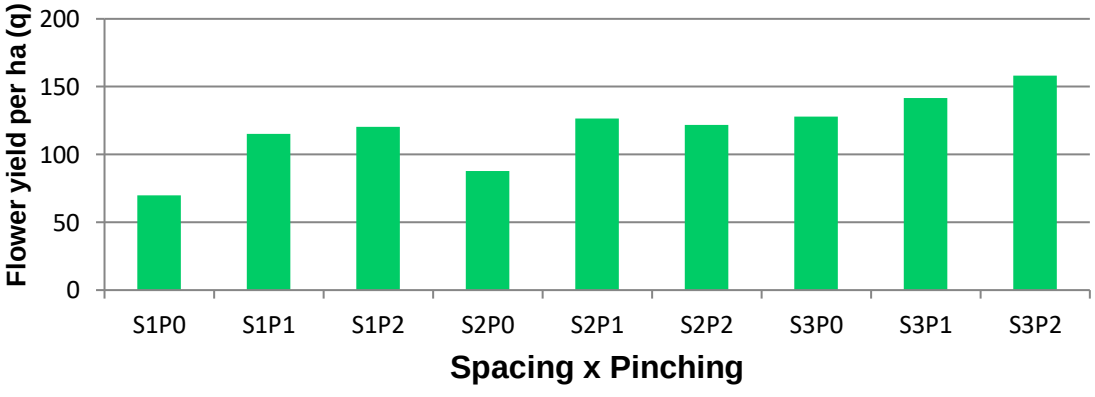


Fig 4.20.3: Effect of interaction on flower yield per ha (q) of marigold



4.21 Weight of seeds per flower (g)

The observations on weight of seeds per floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.21 and illustrated in Fig. 4.21.

The weight of seeds per flower was significantly influenced by the spacing treatments. Weight of seeds per flowerfor spacing was varied from 0.25 g to 0.30 g. The maximum weight of seeds per flower (0.30 g) was recorded with S_1 (45 x 45 cm) and it was statistically superior over rest of the treatments. Whereas the minimum weight of seeds per flower 0.25 g was recorded with S_3 (30 x 30 cm) followed by 0.27 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The weight of seeds per flowerwas significantly influenced by the pinching treatments. Weight of seeds per flowerfor pinching was varied from 0.25 g to 0.31 g. The maximum weight of seeds per flower(0.31 g) was recorded with P_0 (no pinching) and it was statistically superior over rest of the treatments. Whereas the minimum weight of seeds per flower 0.25 g was recorded with P_2 (double pinching) followed by 0.27 g with P_1 (single pinching) and both of these treatment are statistically at par to each other.

The interaction effect between spacing and pinching (Table 4.21) were found to be non-significant. Weight of seeds per flowerfor interaction was varied from 0.23 g to 0.33 g. The spacing of 45 x 45 cm with no pinching (S_1P_0) gave maximum weight of seeds per flower(0.33 g) which was followed by S_2P_0 (0.31 g), S_3P_0 (0.29 g) and S_1P_1 (0.28 g). Whereas spacing (30x30 cm) with double pinching (S_3P_2) gave minimum weight of seeds per flower0.23 g.

Table No. 4.21. Effect of different plant spacing and pinching on weight of seeds per flower

Treatment	Weight of seeds per flower (g)
Spacing (cm)	
45X45 (S_1)	0.30
45X30 (S_2)	0.27
30X30 (S_3)	0.25
SE (m) ±	**0.01**
CD at 5%	**0.02**
Pinching	
No pinching (P_0)	0.31
Single pinching (P_1)	0.27
Double pinching (P_2)	0.25
SE (m) ±	**0.01**
CD at 5%	**0.02**
Spacing x Pinching	
S_1P_0	0.33
S_1P_1	0.28
S_1P_2	0.27
S_2P_0	0.31
S_2P_1	0.27
S_2P_2	0.24
S_3P_0	0.29
S_3P_1	0.25
S_3P_2	0.23
SE (m) ±	**0.01**
CD at 5%	**NS**

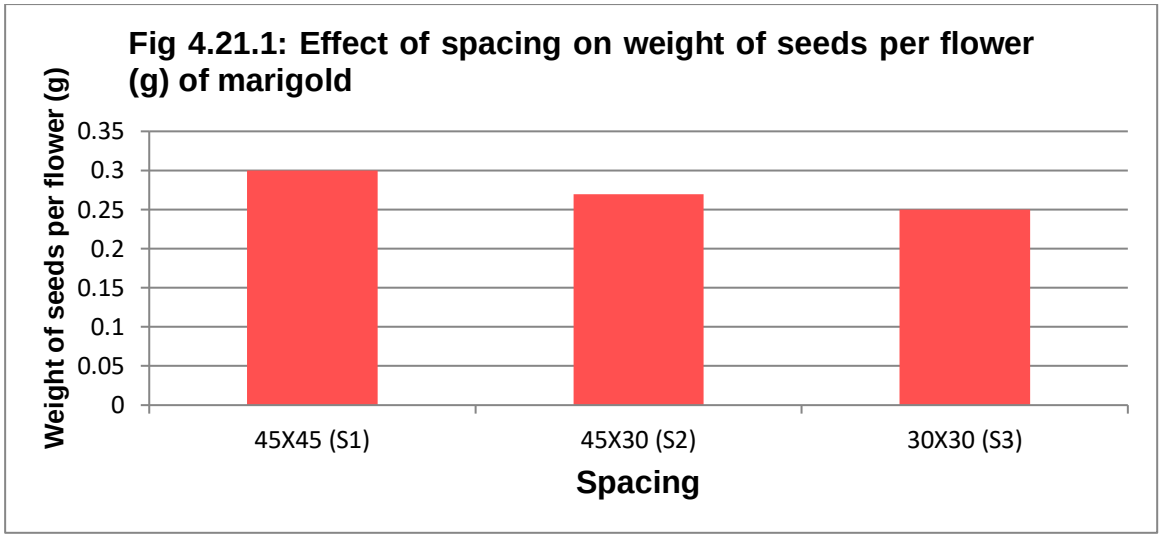


Fig 4.21.1: Effect of spacing on weight of seeds per flower (g) of marigold

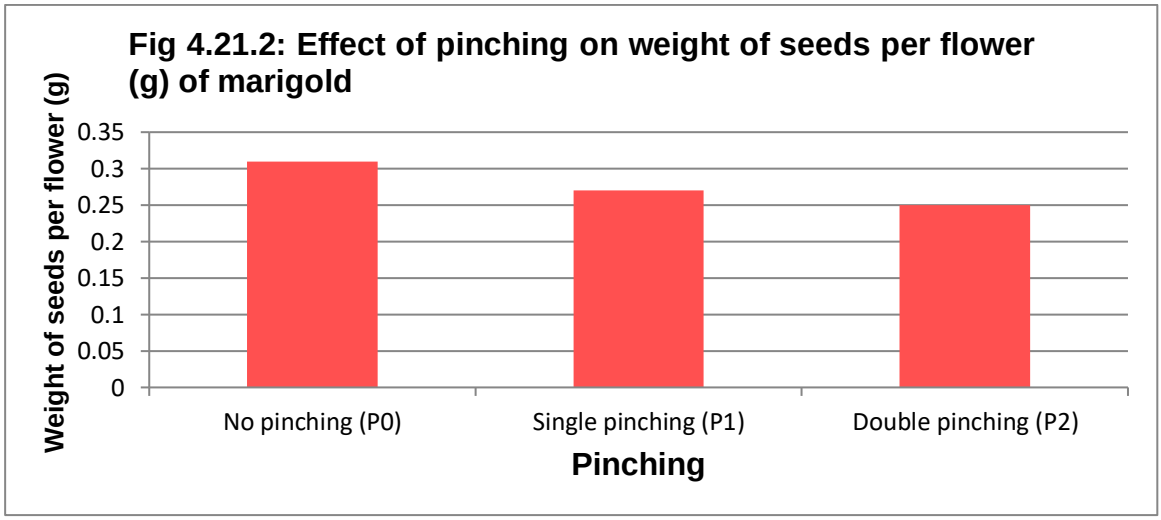


Fig 4.21.2: Effect of pinching on weight of seeds per flower (g) of marigold

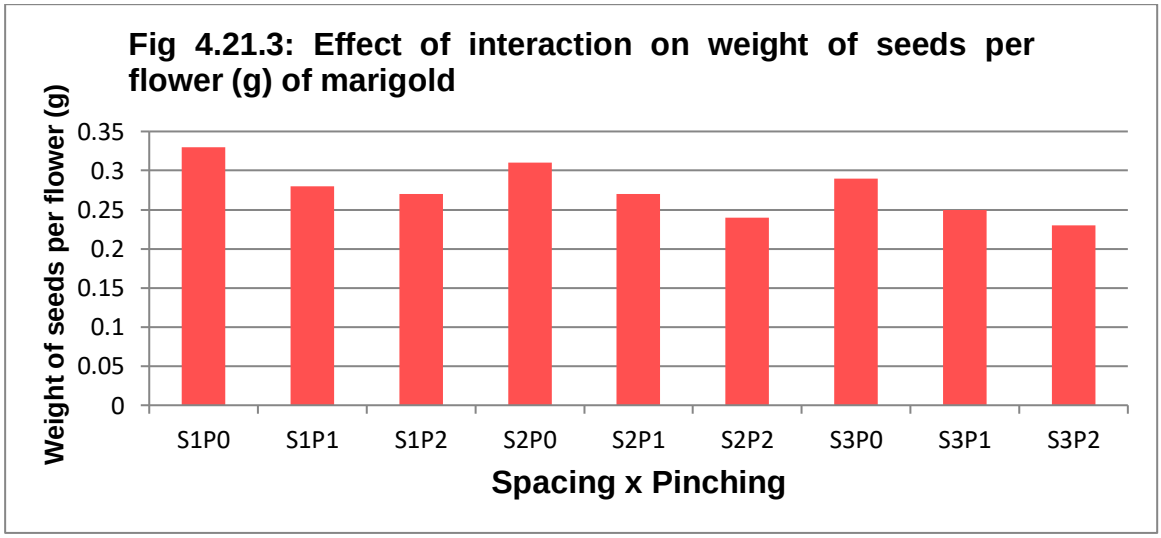


Fig 4.21.3: Effect of interaction on weight of seeds per flower (g) of marigold

4.22 100 seed weight (g)

The observations on 100 seed weightas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.22 and illustrated in Fig. 4.22.

The 100 seed weightwas significantly influenced by the spacing treatments. 100 seed weightfor spacing was varied from 0.17 g to 0.20 g. The maximum 100 seed weight(0.20 g) was recorded with S_1 (45 x 45 cm) followed by 0.18 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum 100 seed weight0.17 g were recorded with S_3 (30 x 30 cm).

The 100 seed weightwas significantly influenced by the pinching treatments. 100 seed weightfor pinching was varied from 0.15 g to 0.21 g. The maximum 100 seed weight0.21 g was recorded with P_0 (no pinching) followed by 0.18 g with P_1 (single pinching). Whereas the minimum 100 seed weight0.15 g was recorded with P_2 (double pinching) and all of these treatments are statistically at par to each other.

The interaction effect between spacing and pinching (Table 4.22) were found to be non-significant. 100 seed weightfor interaction was varied from 0.14 g to 0.22 g. The spacing of 45 x 45 cm with no pinching (S_1P_0) gave maximum weight of 100 seed weight(0.22 g) which was followed by S_1P_1 (0.21 g), S_2P_0 (0.21 g) and S_3P_0 (0.20 g). Whereas spacing (30 x 30 cm) with double pinching (S_3P_2) gave minimum weight of 100 seed weight(0.14 g).

Table No. 4.22. Effect of different plant spacing and pinching on 100 seed weight

Treatment	100 seed weight
Spacing (cm)	
45X45 (S_1)	0.20
45X30 (S_2)	0.18
30X30 (S_3)	0.17
SE (m) ±	**0.01**
CD at 5%	**0.02**
Pinching	
No pinching (P_0)	0.21
Single pinching (P_1)	0.18
Double pinching (P_2)	0.15
SE (m) ±	**0.01**
CD at 5%	**0.02**
Spacing x Pinching	
S_1P_0	0.22
S_1P_1	0.21
S_1P_2	0.16
S_2P_0	0.21
S_2P_1	0.17
S_2P_2	0.15
S_3P_0	0.20
S_3P_1	0.15
S_3P_2	0.14
SE (m) ±	**0.01**
CD at 5%	**NS**

Fig 4.22.1: Effect of spacing on 100 seed weight (g) of marigold

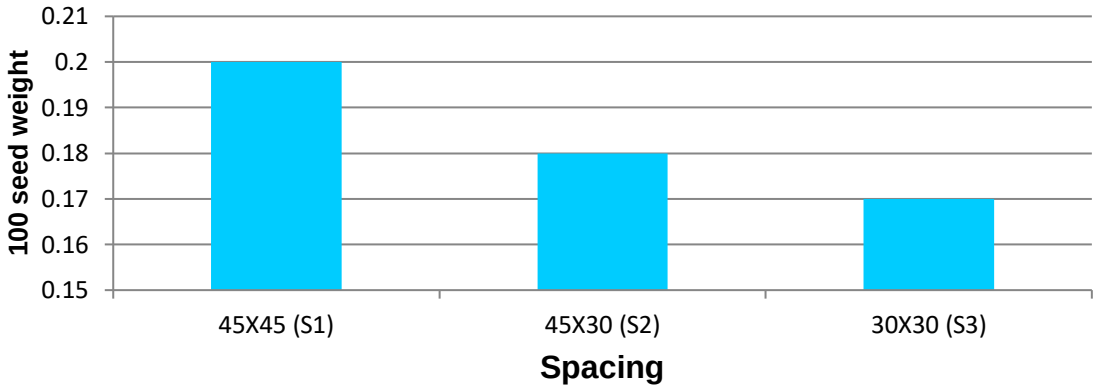


Fig 4.22.2: Effect of pinching on 100 seed weight (g) of marigold

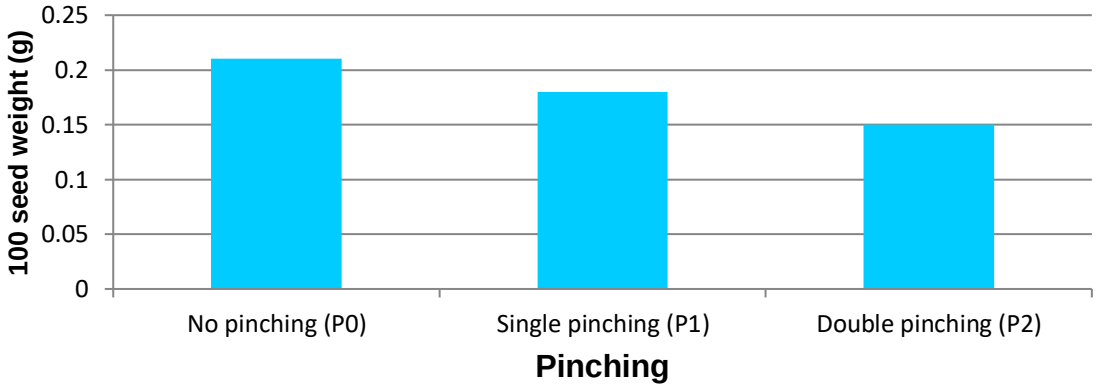
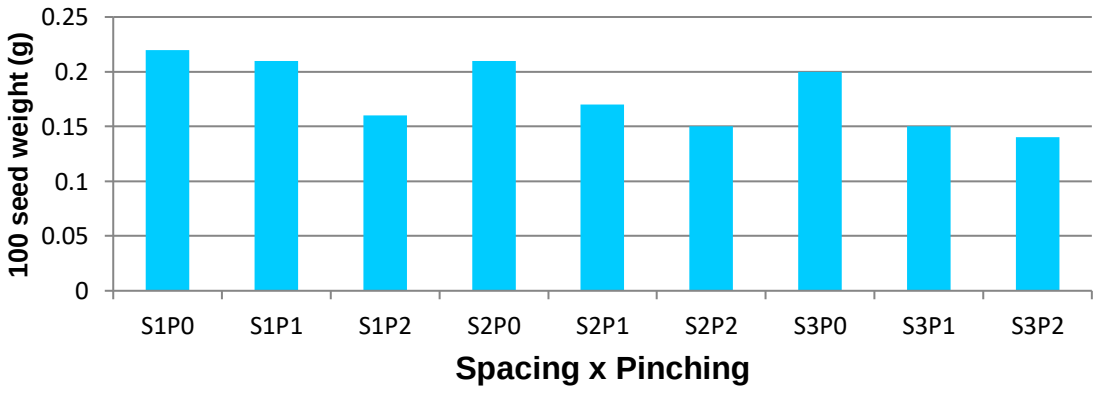


Fig 4.22.3: Effect of interaction on 100 seed weight (g) of marigold



4.23 Seed yield per plant (g)

The observations on seed yield per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.23 and illustrated in Fig. 4.23.

The seed yield per plantwas significantly influenced by the spacing treatments. Seed yield per plantfor spacing was varied from 10.76 g to 12.67 g. The maximum seed yield per plant(12.67 g) was recorded with S_1 (45 x 45 cm) followed by 11.77 g with S_2 (45 x 30 cm). Whereas the minimum seed yield per plant(10.76 g) was recorded with S_3 (30 x 30 cm) and all of these treatments are statistically differ to each other.

The seed yield per plantwas significantly influenced by the pinching treatments. Seed yield per plantfor pinching was varied from 10.20 g to 13.41 g. The maximum seed yield per plant(13.41 g) was recorded with P_0 (no pinching) followed by 11.58 g with P_1 (single pinching). Whereas the minimum seed yield per plant10.20 g was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

The interaction effect between spacing and pinching (Table 4.23) were found to be significant. Seed yield per plantfor interaction was varied from 8.00 g to 14.20 g. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum weight of seed yield per plant(14.20 g) which was followed by S_2P_0 (13.10 g), S_3P_0 (12.93 g) and S_1P_1 (11.98 g). Whereas spacing (30 x 30 cm) with double pinching (S_3P_2) gave minimum seed yield per plant(8.00 g). The treatment combinations S_1P_0 and S_2P_0 were statistically at par to each other and superior over rest of the treatments except S_3P_0.

Table No. 4.23. Effect of different plant spacing and pinching on seed yield per plant (g)

Treatment	Seed yield per plant (g)
Spacing (cm)	
45X45 (S_1)	12.67
45X30 (S_2)	11.77
30X30 (S_3)	10.76
SE (m) ±	**0.22**
CD at 5%	**0.64**
Pinching	
No pinching (P_0)	13.41
Single pinching (P_1)	11.58
Double pinching (P_2)	10.20
SE (m) ±	**0.22**
CD at 5%	**0.64**
Spacing x Pinching	
S_1P_0	14.20
S_1P_1	11.98
S_1P_2	11.82
S_2P_0	13.10
S_2P_1	11.43
S_2P_2	10.78
S_3P_0	12.93
S_3P_1	11.34
S_3P_2	8.00
SE (m) ±	**0.37**
CD at 5%	**1.117**

Fig 4.23.1: Effect of spacing on seed yield per plant (g) of marigold

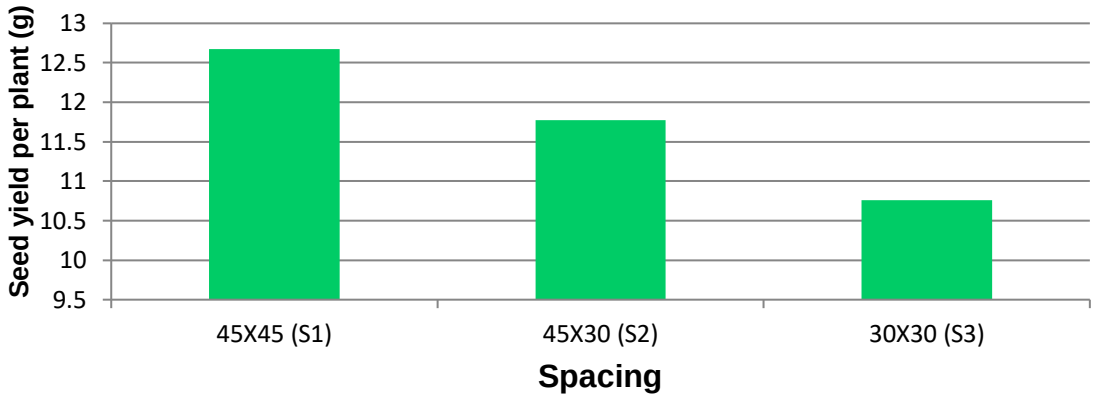


Fig 4.23.2: Effect of pinching on seed yield per plant (g) of marigold

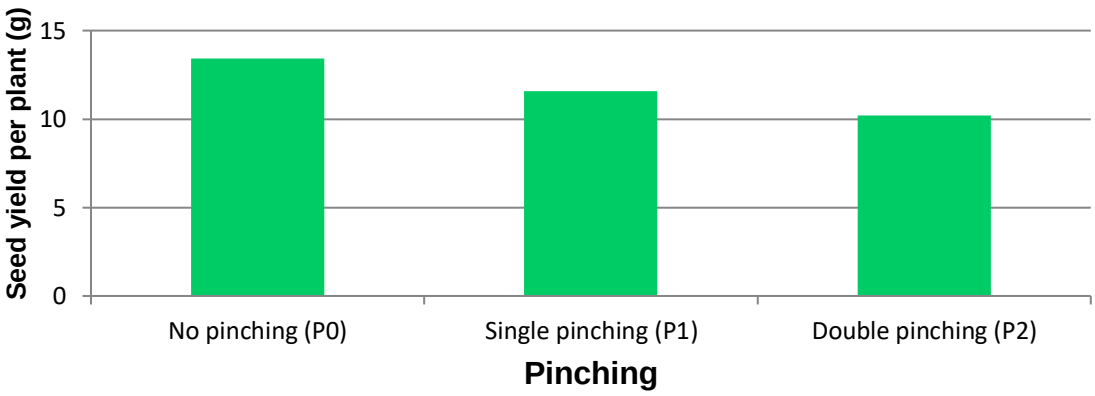
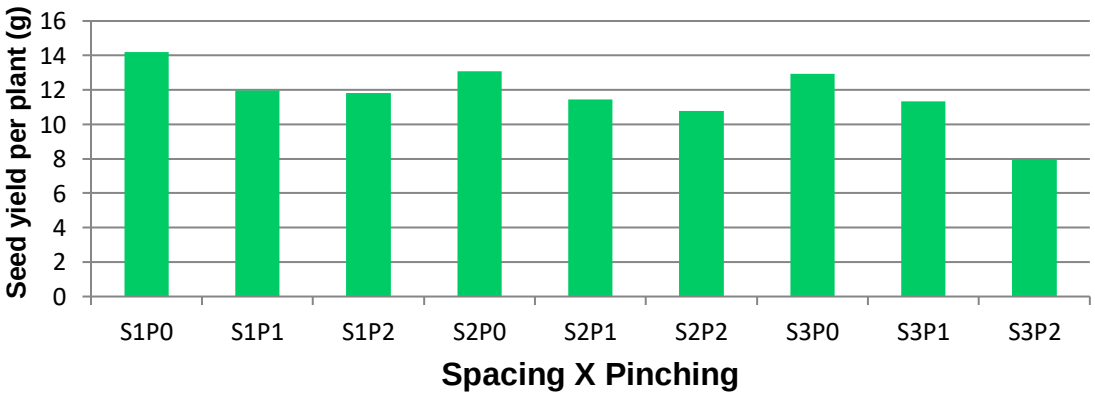


Fig 4.23.3: Effect of interaction on seed yield per plant (g) of marigold



CHAPTER - V

DISCUSSION

In this chapter, an attempt has been made to discuss the experimental findings in the present investigation entitled "**Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching**". The findings described in the preceding chapter have been critically discussed here in detail.

Growth parameters

5.1 Plant height (cm)

The observation on plant height as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.1.

The plant height at 60 days after transplanting was significantly influenced by the spacing treatments. The maximum plant height (70.62 cm) was recorded with S_3 (30 x 30 cm) followed by 67.53 cm with S_2 (45 x 30 cm) whereas minimum plant height was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

The results were similar line for the plant height in marigold was also observed by Kumar *et al*. (2012) and Meena *et al.* (2015).

The increased plant height in closer spacing might be due to intra-plant competition for light, moisture, space and aeration. This resulted in elongation of main stem; increase in stem length may be due to elongation of cells and number of cells due to cell division (Singh *et al.* 2018).

Similarly, the plant height at 60 days after transplanting was significantly influenced by the pinching treatments. The maximum plant height (70.09 cm) was recorded with P_0 (no pinching) followed by 67.11 cm with P_1 (single pinching) where as minimum plant height was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

The results were similar line for the plant height in marigold was also observed by Kumar *et al*. (2012) and Meena *et al.* (2015).

The maximum plant height was observed under without pinching treatment which was due to the suppression of apical growth by pinching process and diversion of plant assimilates towards the initiation and development of side branches. The reduction in plant height might be attributed due to upward growth of main shoots tapped and neutralized the effect of apical dominance which caused a cessation of further plant growth (Meena *et al.* 2015 and Kumar *et al*. 2012).

The interaction effect between spacing and pinching (Table 4.1) were found to be significant at 60 days after transplanting. The spacing of 30x30 cm with no pinching (S_3P_0) gave maximum plant height (74.73 cm) which was followed by S_3P_1 (70.87 cm), S_2P_0 (69.27 cm) and S_2P_1 (67.20 cm). Whereas, wider spacing (45x45 cm) with double pinching (S_1P_2) gave minimum plant height 61.47 cm followed by S_1P_1 (63.27 cm). Both of these treatments are statistically at par to each other and differ over rest of the treatments.

This result might be due to intra-plant competition for light, moisture, space and aeration with upward growth of main shoots tapped and neutralized the effect of apical dominance which caused a cessation of further plant growth (Singh *et al.* 2018, Meena *et al.* 2015 and Kumar *et al*. 2012).

The results were similar line for the plant height in marigold was also observed by Nain *et al*. (2017) and Kour *et al.* (2012).

5.2 Plant spread (cm)

The observations on plant spread as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.2.

The plant spread at 60 days after transplanting was significantly influenced by the spacing treatments. The maximum plant spread (27.29 cm) was recorded with S_1 (45 x 45 cm). Whereas minimum plant spread 25.67 cm was recorded with S_3 (30 x 30 cm) followed by 25.96 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

Similar findings were also reported by Nain *et al.* 2017 and Kumar *et al*. 2012. This increase in plant spread may be attributed to availability of more space, nutrition and air at wider spacing (Nain *et al.,* 2017).

The plant spread at 60 days after transplanting was significantly influenced by the pinching treatments. The maximum plant spread (27.10 cm) was recorded with P_2 (double pinching) followed by 26.32 cm with P_1 (single pinching) and both of these treatment are statistically at par to each other. Whereas the minimum plant spread (25.49 cm) was recorded with P_0 (no pinching).

These results are conformity with Baskaran and Abirami (2016) and Nain *et al.* (2017). The increase in plant spread might be attributed due to upward growth of main shoots tapped and neutralized the effect of apical dominance which caused a cessation of further plant growth (Kumar *et al*. 2012).

The interaction effect between spacing and pinching was found non-significant.

5.3 Number of primary branches per plant

The observations on number of primary branches per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.3.

The number of primary branches per plantat 60 days after transplanting was significantly influenced by the spacing treatments. The maximum number of primary branches per plant(13.33) were recorded with S_1 (45 x 45 cm) followed by 12.67 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum number of primary branches per plant were recorded with S_3 (30 x 30 cm).

This may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing. These

results are in accordance with the findings of Lakshmi *et al.* (2014), Kumar *et al.* (2012) and Singh *et al.* (2018).

Similarly, the number of primary branches per plantat 60 days after transplanting was significantly influenced by the pinching treatments. The maximum number of primary branches per plant(14.16) was recorded with P_3 (double pinching) which was statistically superior to other treatments. Whereas, the minimum number of primary branches per plant 11.76 were recorded with P_0 (no pinching) followed by 12.31 with P_1 (single pinching) and both of these treatments are statistically at par to each other.

The increasing primary branches per plantin pinched plant was mainly due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the primary branches per plant (Sarkar *et al.,*2018).

The results are in close agreement with the findings of Kumar *et al.* (2012) and Nain *et al.* (2017).

The interaction effect between spacing and pinching was found non-significant.

5.4 Number of secondary branches per plant

The observations on number of secondary branches per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.4.

The number of secondary branches per plantat 60 days after transplanting was significantly influenced by the spacing treatments. The maximum number of secondary branches per plant(26.27) was recorded with S_1 (45 x 45 cm) which was statistically superior to other treatments. Whereas minimum number of secondary branches per plant 24.73 were recorded with S_3 (30 x 30 cm) followed by 24.93 with S_2 (45 x 30 cm) and both of these treatments are statistically at par to each other.

This may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing. These results are in accordance with the findings of Lakshmi *et al.* (2014), Kumar *et al.* (2012) and Singh *et al.* (2018).

The number of secondary branches per plantat 60 days after transplanting was significantly influenced by the pinching treatments. The maximum number of secondary branches per plant (32.47) was recorded with P_2 (double pinching) followed by 24.04 with P_1 (single pinching). Whereas minimum number of secondary branches per plant 19.42 were recorded with P_0 (no pinching).

The increasing primary branches per plantin pinched plant was mainly due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the primary branches per plant (Sarkar *et al.,*2018).

The results are in close agreement with the findings of Sarkar *et al.* (2018), Kumar *et al.* (2012) and Nain *et al.* (2017).

The interaction effect between spacing and pinching (Table 4.4) were found to be significant at 60 days after transplanting.The spacing of 45 x 45 cm with double pinching (S_1P_2) gave maximum number of secondary branches per plant33.40 which was followed by S_2P_2 (32.07), S_3P_2 (31.93) and S_2P_1 (24.47). Whereas, closer spacing (30 x 30 cm) with no pinching (S_3P_0) and spacing (45 x 30 cm) with no pinching (S_2P_0) gave minimum number of secondary branches per plant 18.67.

This result may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing as well as removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the primary

branches per plant (Lakshmi *et al.* 2014, Kumar *et al.*, 2012 and Singh *et al.*, 2018, Sarkar *et al.,*2018).

These results are in accordance with the findings of Kumar *et al.* (2012) and Kour et al. (2012).

5.5 Number of leaves per plant

The observation on number of leaves per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.5.

The number of leaves per plantat 60 days after transplanting was significantly influenced by the spacing treatments. The maximum number of leaves per plant(265.03) was recorded with S_1 (45 x 45 cm) followed by 245.69 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum number of leaves per plant225.66 were recorded with S_3 (30 x 30 cm).

This may be due to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing (Lakshmi *et al.*, 2014).

These results are in accordance with the findings of, Khobragade *et al.* (2012) in china aster (*Callistephus chinensis*).

Similarly, the number of leaves per plantat 60 days after transplanting was significantly influenced by the pinching treatments.The maximum number of leaves per plant285.94 was recorded with P_2 (double pinching) followed by 241.04 with P_1 (single pinching). Whereas the minimum number of leaves per plant209.39 were recorded with P_0 (no pinching) and all of these treatments are statistically differ to each other.

The increasing number of leaves per plantin pinched plant was mainly due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal

growth which might have favoured in increasing the number of leaves per plant(Sarkar *et al.,* 2018).

The results are in close agreement with the findings of Sarkar *et al.* (2018), Sathappan (2018) and Singh *et al.* (2017).

The interaction effect between spacing and pinching was found non-significant.

5.6 Stem diameter (cm)

The observation on stem diameter as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.6.

The stem diameter at 60 days after transplanting was significantly influenced by the spacing treatments. The maximum stem diameter (1.09 cm) was recorded with S_1 (45x45 cm) followed by 1.06 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum stem diameter(1.01 cm) was recorded with S_3 (30x30 cm).

This may be due to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing (Lakshmi *et al.*, 2014).

These results are in close conformity with earlier reports of Rathore, H.S. (2007).

The treatment pinching and interaction effect between spacing and pinching was found non-significant for stem diameter.

5.7 Days taken to first bud appearance

The observations on days taken to first bud appearance as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.7.

The days taken to first bud appearance was significantly influenced by the spacing treatments. The minimum days taken to first bud appearance

47.67 days was recorded with S_3 (30 x30 cm) followed by 48.44 days with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other and superior over S_1 (45 x 45 cm) which took maximum days to first bud appearance (50.44 days).

The wider spacing had taken more number of days to first bud appearance due to more vegetative growth. These results are in close conformity with earlier reports of Kour *et al.* (2012), Lakshmi *et al.* (2014) and Khobragade *et al.* (2012).

The pinching treatment and interaction did not significantly influenced by days taken to first bud appearance.

5.8 Bud diameter at full grown stage (cm)

The observations on bud diameter at full grown stageas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.8.

The bud diameter at full grown stagewas significantly influenced by the spacing treatments. The maximum bud diameter at full grown stage(0.96 cm) was recorded with S_1 (45 x 45 cm) and it was superior over other treatments. Whereas the minimum bud diameter at full grown stage (0.87 cm) was recorded with S_3 (30 x 30 cm) followed by 0.89 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

This may be due to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing (Lakshmi *et al.*, 2014).These results are in close conformity with earlier reports of Rathore, H.S. (2007).

The bud diameter at full grown stagewas significantly influenced by the pinching treatments. The maximum bud diameter at full grown stage(0.93 cm) was recorded with P_0 (no pinching) followed by 0.90 cm with P_1 (single pinching). Whereas the minimum bud diameter at full grown stage (0.89 cm) was recorded with P_2 (no pinching).

This might be due tothe accumulation of more assimilates in non-pinching treatment (Baskaran and Abirami, 2017 and R.W. *et al.*, 2017).These results are in close conformity with earlier reports of Rathore, H.S. (2007).

The interaction did not significantly influenced by bud diameter at full grown stage.

5.9 Bud length (cm)

The observation on bud length as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.9.

The bud lengthwas significantly influenced by the spacing treatments. The maximum bud length (1.73 cm) was recorded with S_3 (30 x 30 cm) followed by 1.72 cm with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other. Whereas the minimum bud length 1.69 cm was recorded with S_1 (45 x 45 cm).

These results are in close conformity with earlier reports of Rathore, H.S. (2007).

The bud lengthwas significantly influenced by the pinching treatments. The maximum bud length(1.76 cm) was recorded with P_2 (double pinching) followed by 1.73 cm with P_1 (single pinching) and both of these treatments were statistically at par to each other and superior over P_0 (1.65 cm).

These results are in close conformity with earlier reports of Rathore, H.S. (2007).

The bud lengthwas non-significant with respect of their interaction (spacing x pinching).

5.10 Days taken to first flower opening

The observations on days taken to first flower openingas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.10.

The days taken to first flower openingwas significantly influenced by the spacing treatments.The minimum days taken to first flower opening (57.56 days) was recorded with S_3 (30 x30 cm) followed by 57.67 days with S_2 (45 x 30 cm) and both of these treatments were statistically at par to each other and superior over S_1 (45 x 45 cm) which took maximum days to first flower opening(58.89 days).

The wider spacing had taken more number of days to first flowering due to more vegetative growth. Results are similar to finding of Meena *et al.* (2015) and Kumar *et al.* (2012).

The days taken to first flower openingwas significantly influenced by the pinching treatments. The minimum days taken to first flower opening(57.00 days) was recorded with P_0 (no pinching) followed by 57.78 days with P_1 (single pinching) and both of these treatments were statistically at par to each other and superior over P_2 (double pinching) which took maximum days to first flower opening(59.33 days).

The pinching has significantly delayed the days to first flowering and it is due to the induction of vegetative phase after the break of apical dominance. Results are similar to finding of Meena *et al.* (2015), Kumar *et al*. (2012) and Baskaran and Abirami (2017).

The interaction effect between spacing and pinching (Table 4.10) were found to be non-significant.

5.11 Days taken to 50% flowering

The observations on days taken to 50% flowering as influenced by different plant spacing and pinching were recorded and the data are given in Table 4.11.

The days taken to 50% flowering was significantly influenced by the spacing treatments. The minimum days taken to 50% flowering (63.33 days) were recorded with S_3 (30 x30 cm) which was statistically superior over other treatments. Whereas the maximum days taken to 50% flowering (64.44

days)were recorded with S_1 (45 x 45 cm) followed by 64.22 days with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The wider spacing had taken more number of days to 50% flowering due to more vegetative growth (Meena *et al.*, 2015 and Kumar *et al.,* 2012). These results are in close conformity with earlier reports of Lakshmi *et al.* (2014).

The days taken to 50% flowering was significantly influenced by the pinching treatments. The minimum days taken to 50% flowering (63.44 days) was recorded with P_0 (no pinching) followed by 64.00 days with P_1 (single pinching) and both of these treatments were statistically at par to each other. Whereas the maximum days taken to 50% flowering (64.56 days) were recorded with P_2 (double pinching).

It might be due to the fact that new shoots which emerged after pinching entered into vegetative phase and took time to become physiologically mature to bear flowers. Results are similar to finding of Prakash *et al.* (2016), R.W. *et al.* (2017) and Khan *et al.* (2018).

The interaction did not significantly influenced by the days taken to 50% flowering.

5.12 Fresh weight of flower (g)

The observation on fresh weight of floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.12.

The fresh weight of flowerwas significantly influenced by the spacing treatments. The maximum fresh weight of flower(4.70 g) was recorded with S_1 (45 x 45 cm) followed by 4.46 g with S_2 (45 x 30 cm). Whereas the minimum fresh weight of flower(4.33 g) was recorded with S_3 (30 x 30 cm) and all of these treatments are statistically differ to each other.

It was due to proper availability of light, air and space. These results are in conformity with the findings of Kumar *et al*. (2012) and Singh *et al*. (2015).

Similarly, the fresh weight of flower was significantly influenced by the pinching treatments.The maximum fresh weight of flower (4.74 g) was recorded with P_0 (no pinching) followed by 4.49 g with P_1 (single pinching). Whereas the minimum fresh weight of flower(4.26 g) was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

This might be due tothe accumulation of more assimilates in non-pinching treatment. These results are in similar with the findings of Baskaran and Abirami (2017) and R.W.*et al.* (2017).

The interaction effect between spacing and pinching (Table 4.12) were found to be significant. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum fresh weight of flower(5.09 g) which was followed by S_1P_1 (4.68 g), S_2P_0 (4.63 g) and S_3P_0 (4.49 g) and all of these treatment are statistically at par to each other except S_1P_0. Whereas, closer spacing (30x30 cm) with double pinching (S_3P_2) gave minimum fresh weight of flower(4.19 g) followed by S_2P_2 (4.26 g), S_3P_1 (4.32 g) and S_1P_2 (4.33 g) and all of these treatment are statistically at par to each other.

This result was due to proper availability of light, air and space as well as the accumulation of more assimilates in non-pinching treatment. These results are in similar with the findings of Kumar *et al.* (2012), Kour *et al.* (2012), Nain *et al.* (2017) and Khobragade *et al.* (2012).

5.13 Dry weight of flower (g)

The observation on dry weight of floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.13.

The dry weight of flowerwas significantly influenced by the spacing treatments. The maximum dry weight of flower(0.64 g) was recorded with S_1 (45 x 45 cm) followed by 0.61 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum dry weight of flower0.59 g was recorded with S_3 (30 x 30 cm).

It was due to proper availability of light, air and space. These results are in conformity with the findings of Nain *et al*. (2017).

Similarly, the dry weight of flower was significantly influenced by the pinching treatments. The maximum dry weight of flower (0.65 g) was recorded with P_0 (no pinching) which was statistically superior over other treatments. Whereas the minimum dry weight of flower (0.58 g) was recorded with P_2 (double pinching) followed by 0.61 g with P_1 (single pinching) and both of these treatment are statistically at par to each other.

This might be due tothe accumulation of more assimilates in non-pinching treatment. These results are in similar with the findings of Nain *et al*. (2017) and Singh *et al.* (2017).

The interaction between spacing and pinching did not significantly influenced by the dry weight of flower.

5.14 Flower diameter (cm)

The observation on flower diameteras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.14.

The flower diameterwas significantly influenced by the spacing treatments. The maximum flower diameter(4.50 cm) was recorded with S_1 (45 x 45 cm) and it was statistically differ to other treatments. Whereas the minimum flower diameter(4.29 cm) was recorded with S_3 (30 x 30 cm) followed by 4.36 cm with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

This increased in flower diameter and flower weight at wider spacing may be due to well establishment of the plant, which intern resulted in big size and weighted flower. These results are in accordance with the findings of Singh *et al.* (2018) and Nain *et al.* (2017).

The flower diameterwas significantly influenced by the pinching treatments. The maximum flower diameter(4.70 cm) was recorded with P_0 (no pinching) followed by 4.41 cm with P_1 (single pinching). Whereas the

minimum flower diameter(4.04 cm) was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

This decrease in flower diameter might be at-tribute to the fact that in pinched plant energy is shared by the developing side branches, while in case of un-pinched plants the energy sharing is limited to the flower developing on main branch only. These results are in accordance with the findings of Singh *et al.* (2018), Nain *et al.* (2017) and Singh *et al*. (2017).

The interaction effect between various pinching and spacing levels was found non- significant in influencing diameter of flower.

5.15 Duration of flowering

The observation on duration of flowering as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.15 and illustrated in Fig. 4.15.

The duration of flowering was significantly influenced by the spacing treatments. The maximum duration of flowering (84.33 days) was recorded with S_1 (45 x 45 cm) and it was statistically superior over other treatments. Whereas the minimum duration of flowering (67.89 days) were recorded with S_3 (30 x 30 cm) followed by 70.44 days with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

More flowering period at wider spacing may be due to the fact that wider spaced plants have less competition for nutrient, water and light without any shedding effect. Similar findings were also reported by Nain *et al.* (2017) and Kour *et al.* (2012) in African marigold.

The duration of flowering was significantly influenced by the pinching treatments. The maximum duration of flowering (79.33 days) was recorded with P_2 (double pinching) followed by 74.33 days with P_1 (single pinching). Whereas the minimum duration of flowering (69.00) days were recorded with P_0 (no pinching) and all of these treatments are statistically differ to each other.

This might be due to the fact that by removing the apical portion, the new shoots which emerge on the pinched plants took more time for initiation and mature. These results are in close conformity with earlier reports of Kour et al. (2012) and Nain et al. (2017).

The interaction effect between spacing and pinching (Table 4.15) were found to be significant. The spacing of 45x45 cm with double pinching (S_1P_2) gave maximum duration of flowering (94.67 days) which was followed by S_1P_1 (83.33 days) and both of these treatments are statistically superior over other treatments. Whereas, closer spacing (30x30 cm) with no pinching (S_3P_0) gave minimum duration of flowering (64 days) followed by S_2P_0 (68.00 days) and S_3P_1 (69 days) and they are statistically at par to each other.

This result may be due to the fact that wider spaced plants have less competition for nutrient, water and light without any shedding effect resulted in in-creased spike weight with increasing levels of spacing as well as removing the apical portion, the new shoots which emerge on the pinched plants took more time for initiation and mature (Kour *et al.,* 2012). These results are in close conformity with earlier reports of Kumar *et al.* (2012) and Nain *et al.* (2017).

5.16 Chlorophyll content in leaves (SPAD value)

The observations on chlorophyll content in leavesas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.16.

The chlorophyll content in leaveswas significantly influenced by the spacing treatments. The maximum chlorophyll content in leaves(40.51) was recorded with S_3 (30 x 30 cm) and it was statistically superior over other treatments. Whereas the minimum chlorophyll content in leaves(29.70) were recorded with S_1 (45 x 45 cm) followed by 31.88 with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

Similarly, the chlorophyll content in leaveswas significantly influenced by the pinching treatments. The maximum chlorophyll content in leaves(39.15) was recorded with P_2 (double pinching) and it was statistically

superior over other treatments. Whereas the minimum chlorophyll content in leaves(29.20) were recorded with P_0 (no pinching) followed by 33.75 with P_1 (single pinching) and both of these treatment are statistically at par to each other.

These results are in close conformity with earlier reports of Sarkar *et al.* (2018).

The interaction effect between various pinching and spacing levels was found non- significant in influencing chlorophyll content in leaves.

5.17 Carotenoids in petals (mg/g)

The observation on carotenoids in petals as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.17.

The carotenoids in petalswere significantly influenced by the spacing treatments. The maximum carotenoids in petals (21.51 mg/g) was recorded with S_3 (30 x 30 cm) and it was statistically superior over other treatments. Whereas the minimum carotenoids in petals(16.03 mg/g) were recorded with S_1 (45 x 45 cm) followed by 17.28 mg/g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The carotenoids in petalswere significantly influenced by the pinching treatments. The maximum carotenoids in petals(19.67 mg/g) was recorded with P_2 (double pinching) followed by 18.33 mg/g with P_1 (single pinching) and both of these treatment are statistically at par to each other and superior over P_0 (16.82 mg/g).

These results are in close conformity with earlier reports of Sathappan (2018).

The interaction effect between various pinching and spacing levels was found non- significant in influencing carotenoids in petals.

5.18 Flower yield per plant (g)

The observations on flower yield per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.18.

The flower yield per plantwas significantly influenced by the spacing treatments. The maximum flower yield per plant(180.22 g) was recorded with S_1 (45 x 45 cm) and it was statistically superior to other treatments. Whereas the minimum flower yield per plant(108.33 g) was recorded with S_3 (30 x 30 cm) followed by 128.67 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

This may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing. These results are in accordance with the findings of Kumar *et al.* (2012) and Lakshmi *et al.* (2014).

The flower yield per plantwas significantly influenced by the pinching treatments. The maximum flower yield per plant(163.67 g) was recorded with P_2 (double pinching) followed by 154.78 g with P_1 (single pinching) and both of these treatment are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per plant (98.78 g).

This was mainly due to production of more number of branches bearing more number of flowers by removing apical dominance of main shoots. Similar results have also been observed by Kumar *et al.* (2012) and Baskaran and Abirami (2017).

The interaction effect between spacing and pinching (Table 4.18) were found to be significant. The spacing of 45 x 45 cm with double pinching (S_1P_2) gave maximum flower yield per plant(218.33 g) which was followed by S_1P_1 (211.00 g) and both of these treatment are statistically at par to each other and superior over rest of the treatments. Whereas, spacing (30 x 30 cm) with no pinching (S_3P_0) gave minimum flower yield per plant(90.00 g) which was

followed by S_2P_0 (95.00 g), S_3P_1 (108.33 g), S_1P_0 (111.33 g) and S_3P_2 (126.67 g). All of these are statistically at par to each other.

This may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing as well as production of more number of branches bearing more number of flowers by removing apical dominance of main shoots (Lakshmi *et al.* 2014 and Baskaran and Abirami 2017). Similar results have also been observed by Kumar *et al.* (2012) and Nain *et al.* (2017).

5.19 Flower yield per plot (kg)

The observations on flower yield per plot as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.19.

The flower yield per plot was significantly influenced by the spacing treatments. The maximum flower yield per plot (4.63 kg) was recorded with S_3 (30 x 30 cm) followed by 3.62 kg with S_2 (45 x 30 cm). Whereas the minimum flower yield per plot (3.30 kg) was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

The plants per unit area were optimum which facilitated better growth of the plants that resulted in higher flower yield per hectare as compared to other spacing's. Similar results were also recordedby Kumar*et al.* (2012) and Lakshmi *et al.* (2014) in marigold.

The flower yield per plotwas significantly influenced by the pinching treatments. The maximum flower yield per plot(4.32 kg) was recorded with P_2 (double pinching) followed by 4.14 kg with P_1 (single pinching) and both of these treatments are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per plot (3.09 kg).

This was mainly due to production of more number of branches bearing more number of flowers by removing apical dominance of main shoots.

Similar results have also been observed by Kumar *et al.* (2012) and Lakshmi *et al.* (2014) in marigold.

The interaction effect between spacing and pinching (Table 4.19) were found to be significant. The spacing of 30 x 30 cm with double pinching (S_3P_2) gave maximum flower yield per plot(5.13 kg) which was followed by S_3P_1 (4.60 kg) and both of these treatments are statistically superior over rest of the treatments. Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum flower yield per plot(2.27 kg) followed by S_2P_0 (2.85 kg), S_1P_1 (3.73 kg) and S_1P_2 (3.90 kg).

The plants per unit area were optimum which facilitated better growth of the plants that resulted in higher flower yield per plot as compared to other spacing's as well as production of more number of branches bearing more number of flowers by removing apical dominance of main shoots (Lakshmi *et al.,* 2014).Similar results have also been observed by Kumar *et al.* (2012) in marigold.

5.20 Flower yield per ha. (q)

The observations on flower yield per ha as influenced by different plant spacing and pinching was recorded and the data are given in Table 4.20.

The flower yield per ha was significantly influenced by the spacing treatments. The maximum flower yield per ha (142.62 q) was recorded with S_3 (30 x 30 cm) followed by 112.09 q with S_2 (45 x 30 cm). Whereas the minimum flower yield per ha 101.84 q was recorded with S_1 (45 x 45 cm) and all of these treatments are statistically differ to each other.

The plants per unit area were optimum which facilitated better growth of the plants that resulted in higher flower yield per hectare as compared to other spacing's. Similar results were also recorded by Kumar *et al.* (2012) and Lakshmi *et al.* (2014) in marigold.

Similarly, the flower yield per hawas significantly influenced by the pinching treatments. The maximum flower yield per ha(133.46 q) was recorded with P_2 (double pinching) followed by 127.75 q with P_1 (single

pinching) and both of these treatment are statistically at par to each other and superior over P_0 (no pinching) which recorded minimum flower yield per ha (95.34 q).

This was mainly due to production of more number of branches bearing more number of flowers by removing apical dominance of main shoots. Similar results have also been observed by Kumar *et al.* (2012) and Lakshmi *et al.* (2014) in marigold.

The interaction effect between spacing and pinching (Table 4.20) were found to be significant. The maximum flower yield per ha (158.13 q) was recorded with S_3P_2 and it was statistically superior over rest of the treatments which was followed by S_3P_1 (141.67 q), S_3P_0 (128.07 q) and S_2P_1 (126.36 q). Whereas spacing (45x45 cm) with no pinching (S_1P_0) gave minimum flower yield per ha(69.95 q).

The plants per unit area were optimum which facilitated better growth of the plants that resulted in higher flower yield per hectare as compared to other spacing's as well as production of more number of branches bearing more number of flowers by removing apical dominance of main shoots (Lakshmi *et al.* 2014).Similar results have also been observed by Kumar *et al.* (2012), Kour *et al.* (2012) and Singh *et al.* (2018) in marigold.

5.21 Weight of seeds per flower (g)

The observation on weight of seeds per floweras influenced by different plant spacing and pinching was recorded and the data are given in Table 4.21.

The weight of seeds per flower was significantly influenced by the spacing treatments. The maximum weight of seeds per flower (0.30 g) was recorded with S_1 (45 x 45 cm) and it was statistically superior over rest of the treatments. Whereas the minimum weight of seeds per flower 0.25 g was recorded with S_3 (30 x 30 cm) followed by 0.27 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other.

The maximum seed yield/flower was recorded to favourable conditions for plant growth and better activity of pollinators resulted into better seed setting. Similar results have also been observed by Meena *et al.* (2015) in marigold.

The weight of seeds per flowerwas significantly influenced by the pinching treatments. The maximum weight of seeds per flower(0.31 g) was recorded with P_0 (no pinching) and it was statistically superior over rest of the treatments. Whereas the minimum weight of seeds per flower 0.25 g was recorded with P_2 (double pinching) followed by 0.27 g with P_1 (single pinching) and both of these treatment are statistically at par to each other.

Weight of seeds per flowerwas maximum in no pinching followed by single pinching and was almost identical. Significantly lower weight of seed per head was observed in double pinching and it might be due to small size of flower. Similar results have also been observed by Mohanty *et al.* (2015) and Meena *et al.* (2015) in marigold.

The interaction effect between various pinching and spacing levels was found non- significant in influencing seed yield/flower.

5.22 100 seed weight (g)

The observations on 100 seed weightas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.22.

The 100 seed weightwas significantly influenced by the spacing treatments. The maximum 100 seed weight(0.20 g) was recorded with S_1 (45 x 45 cm) followed by 0.18 g with S_2 (45 x 30 cm) and both of these treatment are statistically at par to each other. Whereas the minimum 100 seed weight0.17 g were recorded with S_3 (30 x 30 cm).

The maximum 100 seed weightwas recorded to favourable conditions for plant growth and better activity of pollinators resulted into better seed setting. Similar results have also been observed by Meena *et al.* (2015) in marigold.

The 100 seed weightwas significantly influenced by the pinching treatments. The maximum 100 seed weight0.21 g was recorded with P_0 (no pinching) followed by 0.18 g with P_1 (single pinching). Whereas the minimum 100 seed weight0.15 g was recorded with P_2 (double pinching) and all of these treatments are statistically at par to each other.

Weight of seeds per flowerwas maximum in no pinching followed by single pinching and was almost identical. Significantly lower weight of seed per head was observed in double pinching and it might be due to small size of flower in marigold. Similar results have also been observed by Mohanty *et al.* (2015) and Meena *et al.* (2015) in marigold.

The interaction effect between various pinching and spacing levels was found non-significant in influencing 100 seed weight.

5.23 Seed yield per plant (g)

The observations on seed yield per plantas influenced by different plant spacing and pinching was recorded and the data are given in Table 4.23.

The seed yield per plantwas significantly influenced by the spacing treatments. The maximum seed yield per plant(12.67 g) was recorded with S_1 (45 x 45 cm) followed by 11.77 g with S_2 (45 x 30 cm). Whereas the minimum seed yield per plant(10.76 g) was recorded with S_3 (30 x 30 cm) and all of these treatments are statistically differ to each other.

The maximum seed yield per plantwas recorded to favourable conditions for plant growth and better activity of pollinators resulted into better seed setting. Similar results have also been observed by Meena *et al.* (2015) in marigold.

The seed yield per plantwas significantly influenced by the pinching treatments. The maximum seed yield per plant(13.41 g) was recorded with P_0 (no pinching) followed by 11.58 g with P_1 (single pinching). Whereas the minimum seed yield per plant10.20 g was recorded with P_2 (double pinching) and all of these treatments are statistically differ to each other.

Seed yield per plantwas maximum in no pinching treatment followed by single pinching and was almost identical. Significantly lower weight of seed per head was observed in double pinching and it might be due to small size of flower. Similar results have also been observed by Mohanty *et al.* (2015), Meena *et al.* (2015) and Baskaran and Abirami (2017) in marigold.

The interaction effect between spacing and pinching (Table 4.23) were found to be significant. The spacing of 45x45 cm with no pinching (S_1P_0) gave maximum weight of seed yield per plant(14.20 g) which was followed by S_2P_0 (13.10 g), S_3P_0 (12.93 g) and S_1P_1 (11.98 g). Whereas spacing (30 x 30 cm) with double pinching (S_3P_2) gave minimum seed yield per plant(8.00 g). The treatment combinations S_1P_0 and S_2P_0 were statistically at par to each other and superior over rest of the treatments except S_3P_0.

The maximum seed yield per plantwas recorded to favourable environment conditions for plant growth and better activity of pollinators resulted into better seed setting as well as no pinching treatment followed by single pinching and was almost identical. Significantly lower weight of seed per head was observed in double pinching and it might be due to small size of flower (Mohanty *et al.*, 2015 and Baskaran and Abirami (2017).Similar results have also been observed by Meena *et al.* (2015) in marigold.

Chapter - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

6.1 SUMMARY:

The present field experiment on **"Response of African marigold (*Tagetes erecta* L.) cv. PusaNarangiGainda to spacing and pinching"**was conducted at Horticulture Research Farm, in the department of Floriculture and Landscape Architecture, College of Horticulture, Mandsaur, RVSKVV, Gwalior from July 2018 to February 2019.

The experiment was carried out with three treatments of plant spacing i.e., S_1 (45 x 45 cm), S_2 (45 x 30 cm) and S_3 (30 x 30 cm) and employing three pinching treatments viz., P_0 (no pinching), P_1 (single pinching) and P_2 (double pinching). Thus, there were nine treatment combinations, which were replicated three times. Total numbers of plots were twenty seven. The experiment was laid out in factorial randomized block design.

During the course of study, the observations were recorded on growth characters viz., plant height (cm), plant spread (cm), number of primary branches per plant, number of secondary branches per plant, number of leaves per plant and stem diameter (cm). As regards flowering observations on day's taken to first bud appearance, bud diameter at full grown stage (cm), bud length (cm), day's taken to first flower opening, days taken to 50% flowering, fresh weight of flower (g), dry weight of flower (g), flower diameter (cm) and duration of flowering.With respect to post harvest quality and biochemical analysis parameters, chlorophyll content in leaves (SPAD value), carotenoids in petals (mg/g), flower yield per plant (g), flower yield per plot (kg) as well as flower yield per ha. (q). In this study seed yield parameters are also included i.e. weight of seeds per flower (g), 100 seed weight (g) and seed yield per plant (g).

The results of the investigation are summarized as follows:

The maximum plant height (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0 respectively, while the minimum plant height (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2.

The maximum plant spread (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum plant spread (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum number of primary branches per plant was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum number of primary branches per plant was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum number of secondary branches per plant was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum number of secondary branches per plant was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum number of leaves per plant was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum number of leaves per plant was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum stem diameter (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum stem diameter (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The minimum days taken to first bud appearance was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0 respectively while the maximum days taken to first bud appearance was

recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2.

The maximum bud diameter at full grown stage (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum bud diameter at full grown stage (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum bud length (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2 respectively, while the minimum bud length (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0.

The minimum days taken to first flower opening was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0 respectively, while the maximum days taken to first flower opening was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2.

The minimum days taken to 50% flowering was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0 respectively, while the maximum days taken to 50% flowering was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2.

The maximum fresh weight of flower (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum fresh weight of flower (g) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum dry weight of flower (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum dry weight of flower (g) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum flower diameter (cm) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the

minimum flower diameter (cm) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum duration of flowering was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum duration of flowering was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum chlorophyll content in leaves (SPAD value) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2 respectively, while the minimum chlorophyll content in leaves (SPAD value) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0.

The maximum carotenoids in petals (mg/g) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2 respectively, while the minimum carotenoids in petals (mg/g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0.

The maximum flower yield per plant (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_2 (double pinching) and interaction S_1P_2 respectively, while the minimum flower yield per plant (g) was recorded with spacing S_3 (30 x 30 cm), pinching P_0 (no pinching) and interaction S_3P_0.

The maximum flower yield per plot (kg) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2 respectively, while the minimum flower yield per plot (kg) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0.

The maximum flower yield per ha (q) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2 respectively, while the minimum flower yield per ha (q) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0.

The maximum weight of seeds per flower (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum weight of seeds per flower (g) was recorded

with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum 100 seed weight (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum 100 seed weight (g) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

The maximum seed yield per plant (g) was recorded with spacing S_1 (45 x 45 cm), pinching P_0 (no pinching) and interaction S_1P_0 respectively, while the minimum seed yield per plant (g) was recorded with spacing S_3 (30 x 30 cm), pinching P_2 (double pinching) and interaction S_3P_2.

6.2 CONCLUSIONS

On the basis of results obtained from the present investigation, it may be concluded that:

Among the spacing, treatment S_1 (45 x 45 cm) show the best results with respect of most of the parameters (plant spread, number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, stem diameter,bud diameter at full grown stage,fresh weight of flower, dry weight of flower, flower diameter,duration of flowering,flower yield per plant,weight of seeds per flower, 100 seed weight and seed yield per plant) while S_3 (30 x 30 cm) show the best results with respect of rest of the parameters (plant height, days taken to first bud appearance, bud length, days taken to first flower opening, days taken to 50% flowering,chlorophyll content in leaves (SPAD value), carotenoid's in petals (mg/g),flower yield per plot (kg) as well as flower yield per ha).

Among the pinching, treatment P_2 (double pinching) show the best results with respect of most of the parameters (plant spread, number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, stem diameter,bud length, duration of flowering,chlorophyll content in leaves, carotenoid's in petals, flower yield per plant,flower yield per plot as well as flower yield per ha) while P_0 (no pinching) show the best results with respect of rest of the parameters (plant height,

days taken to first bud appearance,bud diameter at full grown stage, days taken to first flower opening, days taken to 50% flowering,fresh weight of flower, dry weight of flower, flower diameter,weight of seeds per flower, 100 seed weight and seed yield per plant).

Among the interaction, treatment S_1P_0 show the best results with respect of bud diameter at full grown stage,weight of flower, dry weight of flower, flower diameter,weight of seeds per flower, 100 seed weight and seed yield per plant. While, S_1P_2 show the best results with respect of plant spread,number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, stem diameter,duration of flowering, flower yield per plant.The interaction treatment S_3P_2 show the best results with respect of these parameters (bud length,chlorophyll content in leaves, carotenoid's in petals,flower yield per plot as well as flower yield per ha) andthe interaction treatment S_3P_0 show the best results with respect of plant height, days taken to first bud appearance, days taken to first flower opening, days taken to 50% flowering.

From above experiment we can conclude that spacing treatment S_3 (30 x 30 cm), pinching treatment P_2 (double pinching) and interaction treatment S_3P_2 has shown best result in terms of yield.

6.3 SUGGESTIONS FOR FUTURE WORK

Based on the results obtained and the experiences gained from the present study, following suggestions are given for future line of work:

1. The experiment may be repeated to confirm the results of the present study.

2. The effect of other factors on marigold flower production like date of planting, drip irrigation, fertigation, fertilizer (N, P &K) application may be studied in coming years.

3. The studies on spacing and pinching may also be carried out for other improved varieties and F_1 hybrids of marigold.

4. The experiment may be carried out in different season and agro-climatic condition of Madhya Pradesh.

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Appendices

Appendix- I: Analysis of variance for the plant height (cm) and plantspread (cm).

Source of variation	D.F.	Mean sum of squares	
		Plant height (cm)	Plant spread (cm)
Replication	2	0.73	1.56
Spacing	2	109.31	6.74
Pinching	2	67.42	5.84
Interaction	4	5.87	0.68
Error	16	1.93	1.34
Total	26		

Appendix- II: Analysis of variance fornumber of primary branches per plant and number of secondary branches per plant.

Source of variation	D.F.	Mean sum of squares	
		Number of primary branches per plant	Number of secondary branches per plant
Replication	2	0.66	0.07
Spacing	2	2.81	6.25
Pinching	2	14.21	393.68
Interaction	4	0.97	0.71
Error	16	0.48	0.20
Total	26		

Appendix- III: Analysis of variance forNumber of leaves per plant and Stem diameter (cm).

Source of variation	D.F.	Mean sum of squares	
		Number of leaves per plant	Stem diameter (cm)
Replication	2	787.09	0.0059
Spacing	2	3489.23	0.0135
Pinching	2	13318.26	0.0054
Interaction	4	148.22	0.0005
Error	16	765.06	0.0028
Total	26		

Appendix- IV: Analysis of variance fordays taken to first bud appearance and bud diameter at full grown stage (cm).

Source of variation	D.F.	Mean sum of squares	
		Days taken to first bud appearance	Bud diameter at full grown stage (cm)
Replication	2	1.37	0.0004
Spacing	2	18.48	0.0201
Pinching	2	10.26	0.0048
Interaction	4	1.81	0.0010
Error	16	3.87	0.0013
Total	26		

Appendix- V: Analysis of variance forbud length (cm) and days taken to first flower opening.

Source of variation	D.F.	Mean sum of squares	
		Bud length (cm)	Days taken to first flower opening
Replication	2	0.0016	0.04
Spacing	2	0.0048	4.93
Pinching	2	0.0325	12.70
Interaction	4	0.0013	0.59
Error	16	0.0011	0.95
Total	26		

Appendix- VI: Analysis of variance fordays taken to 50% flowering and fresh weight of flower (g).

Source of variation	D.F.	Mean sum of squares	
		Days taken to 50% flowering	Fresh weight of flower (g)
Replication	2	0.78	0.01
Spacing	2	3.11	0.31
Pinching	2	2.78	0.51
Interaction	4	0.22	0.05
Error	16	0.61	0.02
Total	26		

Appendix- VII: Analysis of variance fordry weight of flower (g)and flower diameter (cm).

Source of variation	D.F.	Mean sum of squares	
		Dry weight of flower (g)	Flower diameter (cm)
Replication	2	0.0008	0.008
Spacing	2	0.0059	0.109
Pinching	2	0.0110	0.998
Interaction	4	0.0002	0.004
Error	16	0.0010	0.018
Total	26		

Appendix- VIII: Analysis of variance forduration of flowering and chlorophyll content in leaves (SPAD value).

Source of variation	D.F.	Mean sum of squares	
		Duration of flowering	Chlorophyll content in leaves (SPAD value)
Replication	2	4.33	75.63
Spacing	2	704.78	294.11
Pinching	2	240.33	223.15
Interaction	4	52.28	5.58
Error	16	14.17	21.81
Total	26		

Appendix- IX: Analysis of variance forcarotenoids in petals (mg/g)and flower yield/plant (g).

Source of variation	D.F.	Mean sum of squares	
		Carotenoids in petals (mg/g)	Flower yield/plant (g)
Replication	2	0.56	205.48
Spacing	2	74.26	12359.15
Pinching	2	18.23	11138.37
Interaction	4	1.18	1569.54
Error	16	1.86	520.86
Total	26		

Appendix- X: Analysis of variance forflower yield/plot (kg)and flower yield/ha (q).

Source of variation	D.F.	Mean sum of squares	
		Flower yield/plot (kg)	Flower yield/ha (q)
Replication	2	0.05	206.80
Spacing	2	4.32	4051.32
Pinching	2	3.98	3804.13
Interaction	4	0.27	251.65
Error	16	0.07	83.50
Total	26		

Appendix- XI: Analysis of variance forweight of seed/flower (g), 100 seed weight (g)and seed yield/plant (g).

Source of variation	D.F.	Mean sum of squares		
		Weight of seed/flower (g)	100 Seed weight (g)	Seed yield/plant (g)
Replication	2	0.0014	0.0001	0.002
Spacing	2	0.0044	0.0022	8.219
Pinching	2	0.0098	0.0081	23.347
Interaction	4	0.0001	0.0004	2.629
Error	16	0.0006	0.0002	0.416
Total	26			

VITA

The author of this thesis **Jayant Patel S/o Hanuman Patel** was born on 13 July 1995 at at Village Mahantpur, Post-Khajri, Teh.- Damoh, District Damoh, Madhya Pradesh. He passed secondary Examination in the year 2010 from M.P. Board, Bhopal School Government Excellence School Damoh (M.P.) with 83.66 % marks and Senior Secondary School Examination in the year 2012 from M.P. Board, BhopalGovernment Excellence School Damoh (M.P.) with 67 % marks.

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He was allotted an interesting research problem entitled**Response of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda to spacing and pinching**of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

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