EFFECT OF BENZYL ADENINE AND PINCHING ON GROWTH, FLOWERING AND SEED YIELD IN CALENDULA AND PHLOX

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

THESIS SUBMITTED IN PARTIAL FULFILMENT OFTHE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Master of Science (Agriculture)

in

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Supervisor
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Submitted by
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CERTIFICATE

To,
The Registrar (Academic)
Banaras Hindu University
Varanasi-221 005 (India)

Through: **The Head, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221005**

Sir,

I have great pleasure in forwarding the thesis entitled **"Effect of Benzyl adenine and pinching on growth, flowering and seed yield in calendula and phlox"** submitted by **Mr. Vishnu Kumar Sharma**, **ID. No. 20412HOR029** and **Enrolment No. 433635** in partial fulfilment of the requirements for degree of **Master of Science (Agriculture)** in **Horticulture**, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) and placing on record that he has completed the requisite residential requirements as contained in the statutes of the university.

I certify that the work has been carried out solely by **Mr. Vishnu Kumar Sharma** under my supervision and guidance and his findings and data presented in herein are to the best of my knowledge and belief genuine and original.

Thanking you,

Yours faithfully

Forwarded

(Anjana Sisodia)
Supervisor

Head of the Department

BHU capital of knowledge — स्वच्छ भारत एक कदम स्वच्छता की ओर

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Date:
Place: *Varanasi* ***(Vishnu Kumar Sharma)***

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ABBREVIATIONS

%	Percent
/	Per
^{0}E	Degree East
^{0}N	Degree North
a.i.	Active ingredient
BA	Benzyl adenine
C.D.	Critical Difference
cm	centimeter
cv.	Cultivar
d.f.	Degree of freedom
DAT	Days after transplanting
e.g.	For example
ESS	Error sum of square
et al.	(*et albeit*) and elsewhere
etc.	Etcetera
Fig.	Figure
g	Gram
ha	Hectare
i.e.	(*Id est.*) that is
m	Meter
M ha	Million hectare
m^2	Square meter
mg/L	Milligram per liter
mm	Millimeter
MSS	Mean sum of square
Mt	Metric ton
No.	Number
NS	Non-significant
ºC	Degree Celsius
ppm	Parts per million
R.H.	Relative humidity
RSS	Replication sum of square
S.Em ±	Standard Error of Mean
TSS	Treatment sum of square
Viz.	(Videlicet) Namely

Chapter I

INTRODUCTION

Floriculture is the art and knowledge of growing flowers to beautify the space. This is a disciple of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and floristry, comprising the floral industry (Singh and Sisodia, 2017). Flowers are an important element of human life because of their variety in terms of beauty, form, colour, texture and fragrance. It is associated with mankind from the dawn of civilization. The pleasant and vibrant colour in flowers signifies strength, purity, happiness, emotions and instantly affect our mood. These are used for various purposes in our day-to-day life like worshipping, religious, social functions, weddings, interior decoration and self-adornment.

Ornamental crop cultivation is practiced in over 145 countries around the world. Japan, Dubai, Canada, The United States, The Netherlands, Germany and The United Kingdom are the top importers of Indian floriculture products (Anonymous, 2021). India diverse agro-climatic conditions, which range from temperate to humid tropics and from sea level to snowline, provide enormous opportunities for the year-round production of all major flowers. The area under flower crops in India is about 312 thousand hectares with 2309 thousand Mt productions of loose flowers and 770 thousand Mt production of cut flowers. The leading states for commercial production of cut flowers are presently confined as West Bengal (28.21%), Karnataka (16.30%) and U.P (9.05%) (Anonymous, 2021).

The annual flowering plants in the garden contribute enormously to the decorative value of the garden. Annuals grow from seed to flower to perish in a single year or season. Furthermore, there is a class of perennials known as plur-annuals, which flower in the first year but do not survive for another year. Many plants that are perennial in their natural habitat are planted as annuals in the temperate area to add beauty to the space. Many biennials and perennials can also be produced as annuals in tropical environments when grown from seed. The majority of flowering annuals have a 3–6 month life cycle. It provides a beautiful display of colour in the garden. Many of these plants are unequalled for their length of flowering, colour range, case of cultivation, generally adaptability, height and shape of the plant. In addition, many of the annuals possess good fragrances. It can be grown in the ground or as potted plants. The uses of annuals, as well as biennials, are many and varied in a garden. They can be grown individually or with perennial plants as mixed borders.

Calendula officinalis L is an annual herb that belongs to the family Asteraceae (Compositae). This flower is commonly known as pot marigold, English marigold or Scottish marigold. The plant is native to the Mediterranean zone and south Europe. This flower gets its name from the Latin word (*calend*) which means the first day of the month, owing to the plant's long flowering period. It is grown in rock gardens, borders, flower beds and balcony plants. It is highly suitable for pots, bedding and window boxes. its flowers are also used as cut flowers. Calendula is a highly beneficial medicinal plant. Herbal cultivation favours cultivars with bright orange flowers.

It is annual and it is upright (20-50 cm) or procumbent, branching, stipitate-glandular and has a strong taproot. Sessile or short petiolate leaves are elliptic, obovate, oblong, oblanceolate to spatulate, 3–12 (16 cm) by 2–5 cm, with entire margins, apex acute, base clasping and sparsely arachnose on both sides. Flower heads (capitula) are borne singly, involucre is campanulate to hemispheric, phyllaries are linear-lanceolate, pubescent and in two series, ray florets 15–50 (>100) in 1–3 or more series, functionally female, with yellow to orange, linear to oblanceolate corolla, central disc florets 20–60 (≥100) hermaphrodite but functionally male. Achene is curved and tuberculateor transversely ridged.

There are many varieties available in different colours. Important varieties in orange colour are Orange King, Grandiflora, Campfire whereas in yellow colour are Golden Emperor, Golden King, Sunshine and Yellow Colossal.

The global pot marigold flower trade is estimated to be worth Rs.500 crores. China, India and Peru are the top producers and exporters of pot marigold flowers in the country. The major importing countries are the United States and Europe.

Another flower, *Phlox drummondii* (commonly annual phlox or Drummond's phlox) is an annual flowering plant in the genus phlox of the family polemoniaceae. It is also known as star flower. It is native to The United States of America especially in the region of Texas.The genus name is derived from the Greek word ‘phlox’ meaning flame. The phlox was introduced in America in 1835 (Walter, 1933). The species is named for Thomas Drummond, who sent seeds from Texas to England in 1835. Phlox is a dwarf annual and grows about 15-40 cm tall. Plants are bushy with medium sized, narrow and pointed leaves. The flowers are produced in clusters at the end of branches well above the foliage and cover the whole plant. Individual blooms are petite, measuring approximately 2 cm in diameter and having round or pointed petals. Blooms are in terminal clusters and are trumpet-shaped with a short, narrow tube. White, cream, pale yellow, rose, pink, salmon, mauve, blue, red, scarlet, red, crimson and other colours are available.

In both groups of it, such as Grandiflora with large flowers and Nana Compacta with dwarf and compact plants, there are numerous varieties in mixed or separate colours. Snowball, Vermilion, Coccinea, Ford Hook, Art Shades Brilliant, Yellow Beauty, Blue Beauty and others are some of the most popular Grandiflora varieties. Globe, Cecily, and Beauty are popular Nana Compacta varieties. Star phlox varieties such as Cuspidata and Twinkle are excellent. Tetraploid varieties with stronger stems and larger blooms, such as Tetra Road and Giant Tetra, are also available and popular. Phlox are pollinated by lepidoptererans and are largely self-incompatible Auxin, gibberellin, ethylene, cytokinin and abscisic acid are the primary plant growth regulators (Margrethe and Michael, 1997). Plant growth regulators regulate plant development by acting as either inhibitors or promoters, depending on the dose concentration and internal plant features. Cytokinin’s are N_6 -substituted adenine derivatives and a class of plant hormones involved in plant growth and development. 6-Benzyladenine also called 6-benzylaminopurine is a synthetic cytokinin. It is a first-generation synthetic cytokinin that stimulates cell division and causes plant growth and development responses, such as establishing blooms and increasing fruit richness. The application of BA has increased shoot to root ratios, increased production of ethylene, lowered stomatal resistance, increased leaf expansion and stimulated protein synthesis. BA is the most widely utilized and successful cytokinin in micropropagation now a days. However, when applied to field crops, this showed disappointing results in delaying senescence.

The procedure of pinching deals with the removal of a shoot's growing point as well as few leaves. The two main goals of this operation are to promote branching for bushier growth and/or the production of flower buds on the pinched branch. It is mostly done on annuals and herbaceous perennials, with flowering trees requiring very little. This is done at a stage when the plants are young and between 7 and 15 cm in height, depending on their habits of growth. It often happens that one shoot of a plant starts growing vigorously at the expense of the others. Stopping this strong shoot at the proper stage is likely to encourage the growth of the weaker shoots and finally, a shapely plant is obtained. Stopping may involve only the pinching of the main stem, or both the main stem and the side shoots to obtain a bushier plant. One main disadvantage of stopping is that some plant diseases such as those caused by a virus may get transmitted through the pinching blade from a diseased plant to a healthy one. Therefore, as far as possible pinching should be done by snapping with hand. The main purpose of pinching is to encourage branching to produce a bushy growth and the production of a greater number of flowers, ultimately more flower yield. Therefore, keeping the above facts in mind, the present study will concern about the "**Effect of BA and pinching on growth, flowering and seed yield parameters in calendula and phlox"** with the following objectives.

1. To find out the effect of benzyl adenine and pinching on various growth parameters in calendula and phlox.
2. To find out the effect of benzyl adenine and pinching on various flowering and seed yield parameters in calendula and phlox.

Chapter II

REVIEW OF LITERATURE

The influence of benzyl adenine and pinching applications can play a vital role in seed yield and quality for obtaining maximum returns per unit area in calendula and phlox. There is scanty information on both the crop and the seed production aspects. However, the available findings relevant to the study have been reviewed in this chapter.

The review of literature is presented under the following headings

2.1 Effect of benzyl adenine on growth, flowering and seed yield attributes in various flowering crops.

2.2 Effect of pinching on growth, flowering and seed yield attributes in various flowering crops.

2.1 Effect of benzyl adenine on growth, flowering and seed yield parameters in various flowering crops

2.2.1 Effect of BA on growth parameters

Fujii and Sasaki (2000) carried out an investigation into non-branching types and branching types of chrysanthemums. It was found that the BA was best with vegetative parameters like a number of branches and side shoots. The best result was noted at BA @ 300ppm, for the highest branches.

Singh and Sharma (2004) conducted an experiment on the effects of growth and seed attributes in *Calendula officinalis* and found that foliar application of benzyl adenine (BA) at 100 ppm resulted in the maximum number of leaves per plant.

Kumar *et al*. (2012) worked on the gladiolus cvs. Candyman. Healthy, sprouted and uniform corms (5.5–6.0 cm in diameter) were soaked with benzyl amino purine (BAP) at 25, 50, 75, 100 and 150 ppm and in tap water as a control for 24 hours before planting. It was reported that soaked treatment of all levels of BA significantly affected the growth, flower and corm production.

Hosseini *et al.* (2015) worked on marigold using different PGR with different levels of thiamine, ascorbic acid and benzyl adenine. It was observed that the highest total fresh weight, shoot and root dry weight were obtained in the combined treatments of BA.

Naji *et al*. (2015) investigated the effect of benzyl adenine on hybrid lily at different doses of Cycocel (100 mg/l), Indole butyric acid solution (50 mg/l) and benzyl adenine (50 mg/l). BA 50 mg/l was result revealed significant increases in plant height, dry and fresh leaf weight and leaf number.

Sajjad *et al*. (2015) carried out an experiment in which gladiolus flowers were sprayed thrice with different concentrations (0.1, 0.4, 0.7 and 1 mM) of gibberellic acid, benzyl adenine and salicylic acid at three leaf stages, five leaf stages and the slipping stage. It was observed that benzyl adenine application resulted in increased chlorophyll content, total carotenoids and TSS. Foliar application of 1 mM BA increased the plant height.

Mandal *et al*. (2016) conducted an experiment to study the effect of BA on the production of African marigolds (Pusa Narangi Gainda) and found that BA had a direct effect on vegetive parameters. Treatment of BA at 25 ppm recorded maximum B,C and BA at 50 ppm recorded for maximum lateral branches and maximum flowers per plant.

Prakash *et al*. (2016) carried out an investigation in chrysanthemum *(Dendranthema grandiflora)* cv. Vasantika. The experiment was laid out in a Randomized Block Design with 10 treatments comprising 3 different concentrations of each GA_3 at 100, 200 and 300 ppm, NAA (Naphthalene Acetic Acid) at 50, 100 and 150 ppm and BA (Benzyl adenine) at 50, 100 and 150 ppm, along with control (blank water). It was observed that BA at all levels (50, 100, 150 ppm) had no significant effect on the growth parameter because BA and GA_3 have synergistic effects.

Hamad *et al*. (2016) conducted a study on the effects of foliar application of zinc at 0, 50 and 100 ppm, active yeast at 0, 3 and 6 g/l, salicylic acid at 0, 100, 200 and 300 ppm and benzyl adenine at 0, 15, 30 and 45 ppm on the growth and flowering aspects of *Chrysanthemum morifolium* cv. Ramat.

Mohamed *et al*. (2017) evaluated the effects of different concentrations of GA3 (0.0, 100, 200), salicylic acid and BA (0.0, 50 and 100 ppm) on the growth, flowering and postharvest quality of aster (*Symphyotrichum novibelgii L*.) cv. Purple Monarch. They reported that applications of BA @ 100 ppm resulted in the maximum number of primary branches per plant as well as the maximum number of primary branches per plot and plant height.

Kasturi *et al.* (2017) worked on carnation cv. Domingo is under protected cultivation. It was reported that benzyl adenine recorded the maximum number of laterals branches by increasing the concentration and another experiment conducted by Bashiri *et al*. (2017) carried out an investigation on cineraria (*Senecio cruentus*)**.** It was reported that BA at 300 mg/l significantly enhanced the number of shoots, the fresh and dry weight of shoots.

Khattab (2017) investigated BA and GA_3 in *Chrysanthemum morifolium* cv. Zambla White for growth, flowering and chemical analysis. They found that benzyl adenine alone at 100–200 ppm increased fresh and dry weight of leaf.

Soltanmoradi and Sedaghathoor (2018) studied the effects of benzyl adenine and epibrassionolide on *Calendula officinalis*. The plants were sprayed with different concentrations (0, 1, 5 and 10 mg/l) of freshly prepared solutions. The most effective treatment was at 1 mg/l BA which showed a prominent effect on high anthocyanin content and 5 to 10 mg/l BA showed an effect on the highest phenol index.

Gabrel *et al*. (2018) investigated the effects of foliar application at four concentrations (0, 50, 100 and 200 ppm) of benzyl adenine and gibberellic acid each, singly or in combinations (16 treatments) on the vegetative growth, flowering characteristics and some chemical analysis of *Chrysanthemum morifolium* cv. Zambla White. The results showed that using benzyl adenine alone at 100–200 ppm significantly increased branch dry weight. Benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm to activate the vegetative growth of the plants and produce early.

Hasan (2019) investigated the effect of benzyl adenine at various concentrations (0, 50, 100 and 150 mg/l.) on the *Calendula officinalis***.** It was reported that benzyl adenine has a direct effect on vegetative and flowering parameters. Treatment of 150mg (BA) had a positive effect on growth parameters like the highest branch and the number of lateral branches as compared to the control.

Fazeli *et al.* (2019) assessed the effects of different levels of salinity stress and sprayed the benzylaminopurine (benzyl adenine) at 25 and 50 mg/l in winter jasmine. He concluded that results showed that salinity levels and benzyl adenine foliar application have a significant effect on plant growth, number of branches and plant spread.

Ahmed and Al-Saad (2019) they studied the effect of foliar spraying of benzyl adenin e on the growth, flowering and bulb production of tulips. It was noted that BA application at 50 ppm was revealed to be more effective in plant height and stem diameter.

Ramy *et al*. (2019) studied the effects of two synthetic cytokinins (BA and Kinetin) on the growth of gaillardia and concluded that foliar application of BA @ 100 ppm and kinetin @ 25 ppm significantly enhanced number of branches, number of leaves, dry weight of leaves and root weight over a control.

Patel *et al*. (2020), studied the growth and flowering of *Hibiscus rosa-sinensis* using different plant growth regulators (GA3, BA and SA). It was found significant enhanced the plant height, plant spread, more branches and leaf area as compared to untreated plants (control).

Kumar *et al.* **(**2020) studied the effects of GA_3, SA, BA and cycocel on the production of quality flowers and seed production in marigold *(Tagetes erecta L.*). They found that treatment with BA at 100 ppm resulted in the highest numbers of lateral branches per plant and a maximum flower and increased the flower duration as compared to other treatments and control.

El-Ghait *et al*. (2020) investigated the effects of 16 treatments, including four different benzyl adenine (BA) (0.0, 20, 40 and 60 ppm) and four different chemical fertilizer application rates (0.0, 2, 4 and 6 g NPK/pot) on the growth, flowering and chemical composition of Arabian jasmine plants (*Jasminum sambac*) and found that BA at 60 ppm and chemical fertilization rate at 6 g/pot in, the highest number of branches and leaves, fresh weight/plant, the highest number and length of roots/plant, the heaviest fresh weight of roots/plant as well as the richest leaf total carbohydrates, nitrogen, phosphorus and potassium percentages.

Khalil *et al*. (2021) conducted an experiment on the effects of benzyl adenine at different concentrations of 0, 30, 60, and 90 mg/l and at different times of foliar application (7, 14, 21 and 28 days after transplantation), and the results showed that when BAP was applied at 90 mg/l in foliar application, the maximum plant height (g), number of branches per plant, number of leaves per plant, and leaf area (cm^2) were observed in carnation.

Ali *et al.* (2021) worked out an experiment in zinnia by taking two treatments i.e, benzyl adenine (25, 50, 75 and 100 mg/l) and pinching. It was noted that BA application at 100mg/l and pinched at the 6-leaf stage recorded maximum number of branches, leaves and stem thickness.

2.1.2 Effect of BA on flowering parameters

Pharis *et al*. (1972) investigated the effects of GA_3 and BA on *Chrysanthemum morifolium* cv. Pink Champagne at various dose levels (2, 10 or 20 ug) and (1, 5 or 10 ug) and discovered that both GA and BA appeared to be limiting factors for the promotion of flowering in chrysanthemum. The effects of GA and BA were synergistic.

Mutui *et al*. (2003) conducted an experiment in *Alstromeria* to assess the effect of different doses of BA (25, 50, 75 and 100 mg per litre). It was observed that BA (25 and 50 mg/l) increased the number of days to the full opening of primary florets and delayed the onset of flower senescence.

Blanchard and Runkle (2008) assessed the effect of foliar application of BA at different concentrations of 100, 200 and 400 mg/litre in doritaenopsis and phalaenopsis orchid clones. He concluded that plants treated with BA 200 or 400 mg/ l had a visible inflorescence 3–9 days earlier and had a mean of 0.7–3.5 more inflorescences and 3–8 more flowers per plant than non treated plants.

Hassanpour *et al*. (2011) conducted an experiment in *Polianthes tuberose* L (cv. Goldorosht Mahallat) with different levels of BA and GA_3 (0, 50 and 100 ppm) and observed that the largest diameter of floret and vase life of cut flower was BA at 50 and 100 ppm, respectively. Another experiment on tuberose, Kheiry *et al*. (2011) reported that Benzyl adenine increased floret numbers and vase life and preceded flowering.

Janowska (2014) studied the effects of different BA doses (0, 100, 350 and 600 mg/dm^3) on calla lilies. The highest flower yields were noted with a BA concentration of 100-600 mg/dm^3.

Prakash *et al*. (2015) carried out an investigation into chrysanthemum *(Dendranthema grandiflora)* cv vasantika. The experiment was laid out in a Randomized Block Design with 10 treatments comprising 3 different concentrations of each GA3 at 100, 200 and 300 ppm, NAA (Naphthalene Acetic Acid) at 50, 100 and 150 ppm and BA (Benzyl adenine) at 50, 100 and 150 ppm, along with control (blank water). It was that BA at all levels (50, 100 and 150) had no significant effect on the flowering parameter because BA and GA3 have synergistic effects.

Sajjad *et al*. (2015) carried out an experiment in which gladiolus flowers were sprayed thrice with different concentrations (0.1, 0.4, 0.7 and 1 mm) of gibberellic acid, benzyl adenine and salicylic acid at three leaf stages, five leaf stages and the slipping stage. It was observed that application of 1 mm BA increased the spike length, floret spike, corm diameter, corm weight and total cormel weight compared to control.

Hamad *et al*. (2016) conducted a study on the effects of application of zinc at 0, 50 and 100 ppm, active yeast at 0, 3 and 6 g/l, salicylic acid at 0, 100, 200 and 300 ppm and benzyl adenine at 0, 15, 30 and 45 ppm on the growth and flowering aspects of *Chrysanthemum morifolium* cv. Ramat. It was reported that benzyl adenine (BA) 30 ppm significantly enhanced the flowering duration (days), length of the flower stem and length of flowering part on the stem.

Mandal *et al*. (2016) conducted an experiment to study the effect of BA on the production of African marigolds (Pusa Narangi Gainda) and found that BA had a direct effect on flowering parameters. It was reported BA at 25 ppm recorded maximum B, C and BA at 50 ppm recorded maximum flowers per plant.

Mohamed *et al*. (2017) evaluated the effects of different concentrations of GA_3 (0.0, 100, 200), salicylic acid and BA (0.0, 50 and 100 ppm) on the growth, flowering and postharvest quality of aster (*Symphyotrichum novibelgii L*.) cv. Purple Monarch. They reported that applications of BA @ 100 ppm resulted in the increased the number of inflorescence stalks/plant.

Khattab (2017) investigated BA and GA_3 in *Chrysanthemum morifolium* cv. Zambla White for growth, flowering and chemical analysis. They found that benzyl adenine alone at 100–200 ppm increased the period from colour to full opening stage, flowering duration on the plant and inflorescence dry weight significantly.

Gabrel *et al*. (2018) investigated the effects of foliar application at four concentrations (0, 50, 100 and 200 ppm) of each of benzyl adenine and gibberellic acid, singly or in combinations (16 treatments) on the vegetative growth, flowering characteristics, and some chemical analysis of *Chrysanthemum morifolium*. The results showed that using benzyl adenine alone at 100–200 ppm significantly increased the time between showing colour and full opening stage, flowering duration and inflorescence dry weight.

Kapri *et al*. (2018) conducted an experiment on different concentrations of GA_3 (100, 150 and 200 ppm) and BA (100, 150 and 200 ppm) on lilum. Results showed that BA (100 ppm) took the shortest time to show colour on their 1st and 3rd bud. The vase life of cut lilies was maximal with the application of a single dose of BA (100 ppm).

El-Shoura (2018) studied rose cv. Eiffel tower for different chemicals sprayed at different levels, including ethrel at 1000 ppm, BA at 100 ppm or seaweed at 1000 ppm. BA and seaweed increased the number of flowers significantly more than ethrel or control treatments.

Hasan (2019) investigated the effect of benzyl adenine at various concentrations (0, 50, 100 and 150 mg/l) on the *Calendula officinalis.* It was reported that benzyl adenine has a direct effect on flowering parameters. Treatment of 150 mg (BA) had a positive effect on flowering parameters like no. of days required to convert inflorescence bud to full inflorescence and inflorescence diameter**.**

Kumar *et al.* **(**2020) studied the effects of $GA_{3,}$ SA, BA and cycocel on the production of quality flowers and seed production in marigold *(Tagetes erecta L.*). Maximum number of flower and increased flower duration was reported with BA 100 ppm as compared to other treatment and control.

Singh *et al*. (2020) studied the effect of benzyl adenine and putrescine on the flowering and flower quality attributes of chrysanthemum cv. Punjab Shyamli at different levels of putrescine (50, 100 and 150 ppm) and benzyl-adenine (100, 150 and 200 ppm) and found that there were significant floral parameters were delayed and the vase life of cut stems was enhanced by benzyl adenine @ 200 ppm. The maximum delay of the flower opening stage (116.33 days), the number of sprays

(5.00) and the vase life (27.22 days) was obtained with benzyl-adenine @ 200 ppm treatment. Maximum flower diameter was reported with benzyl-adenine at 200 ppm, compared to control.

El-Ghait *et al*. (2020) investigated the effects of foliar spraying with four different benzyl adenine (BA) concentrations (0.0, 20, 40 and 60 ppm) and four different chemical fertilizer application rates (0.0, 2, 4 and 6 g NPK/pot) on the growth, flowering and chemical composition of Arabian jasmine plants (*Jasminum sambac*) and found that BA at 60 ppm and chemical fertilization rate at 6 g/pot in, the highest number of flowers/plant and flowers fresh weight/plant.

Frąszczak *et al*. (2021) conducted an experiment on *calendula officinalis* L cv. Radio by applying different concentrations of benzyl adenine (100, 150 and 200 mg dm3) and different light spectra. It was reported that the results obtained were best at the foliar application of BA at the rate of the plants treated with BA at a concentration of 200 mg dm_3 and illuminated with W+B light were the last to start flowering, although the time of the emergence of subsequent flowers was getting shorter and shorter. On average, BA delayed the flowering of *C. officinalis* "Radio" by 10.8–12.2 days and the development of subsequent inflorescence.

Ali *et al.* (2021**)** worked out an experiment in zinnia with two treatments such as benzyl adenine (25, 50, 75 and 100 mg/L) and pinching. It was noted that BA application at 100 mg/litre and pinched at the 6-leaf stage recorded maximum days to flowering, flower persistency and flowers/plant.

2.1.3 Effect of BA on seed parameters

Singh and Sharma (2004) reported that BA 50 ppm significantly minimum days to taken seed ripening and seed yield/plant in calendula.

Khan *et al*. (2011) conducted an experiment to determine the optimum concentration of BA and GA_3 on dormancy breaking of gladiolus cormels and their effects on cormel growth and subsequent production of gladiolus corm and cormels. It was reported that BA directly affected vegetative shoots. The results revealed that the treatment of BA at 125 ppm resulted in the highest multiple shooting and corm and cormel yield/ha.

Kumar *et al.* **(**2020) observed that BA effect in marigold produced maximum seed yield/plant.

2.2 Effect of pinching on growth, flowering and seed yield parameters in various flowering crops.

2.2.1 Effect of BA on growth parameters

Sen and Naik (1977) reported that pinching reduced plant height, number of nodes and leaf number. However, pinching increased leaf area and total number of branches.

Singh and Baboo (2003) conducted an experiment on the effects of time of pinching at 0, 10, 20 and 30 days after transplanting and nitrogen and potassium from various concentrations in chrysanthemum and reported that pinching at 20 DAT resulted in the highest stem diameter and number of leaves/plant.

Kumar (2011) worked on different levels of pinching (no pinching, 20 and 30 DAT) and nitrogen (0, 50, 100 and 150 kg/ ha) in calendula var. Golden Emperor and reported that pinching reduced the plant height.

Rathore *et al*. (2011) conducted an experiment in two successive years in the spring season where different levels of pinching (no pinching and pinching), ethrel and paclobutrazol (100, 200, 300 and 400 ppm). It was found that pinching treatment significantly decreased the plant height and increased the number of primary branches.

Habiba *et al*. (2012) conducted an experiment to assess the influence of pinching (without pinching and with pinching) on chrysanthemum and found that the pinching show the shortest plant height and maximum number of leaves.

Khobragade *et al*. (2012) carried out an experiment on the effects of planting distance and pinching on growth, flowering and yield in China aster. It was determined that pinching reduced plant height as compared to no pinching.

Singh *et al*. (2015) carried out an experiment on marigold cv. Pusa Narangi Gainda by treating with single pinching (SP), double pinching (DP), SP + 1% nitrogen, SP + 3% nitrogen, DP + 2% nitrogen and DP + 30% nitrogen. It was reported that foliar applications of double pinching + 2% nitrogen significantly increased the number of secondary branches and leaves/plant, plant spread and plant height. Single pinching + 3% nitrogen treatment significantly increased the number of primary branches/plants.

Janabi and Maathedi (2015) conducted an experiment on dahlia plants *var*. Deco mix to study the effect of photoperiod, paclobutrazol and pinching in the roots and flowers planted in pot and observed that photoperiod and pinching shows plants growing without shortening daylight show highest qualities of vegetative growth, such as high vegetative growth and plant height and Pinching treatment does not have any significant effect in root growth.

El-Gamal (2015) conducted an experiment in two successive seasons in which different potassium sources were applied to *Calendula officinalis* (Potassium sulphate, 50% K_2SO_4 + salicylic acid (SA), 50% K_2SO_4 + K-Mag + SA, Flespar+K-magor potassein) and pinching was conducted at various heights (0, 7.5, 10.0 and 12.5 cm). It was found that pinching at 10 cm from the soil surface of the main stem was the best for different growth parameters and flower yield, and 50% potassium sulphate with K-Mag + SA and pinching at 10 cm achieved improved growth and flower yield with 60% over the control.

Prakash *et al*. (2016) investigated the effects of season and pinching on the growth and yield characteristics of African marigold and reported that pinching had a significant positive effect on African marigold growth, flowering and yield.

Salve *et al*. (2016) studied the effect of pinching on chrysanthemum cvs. Shubra, Heritage, Sonali Tara, Piwalirewadi and Pandharirewadi were tested at four levels of pinching and found that among chrysanthemum varieties, padari and revadi recorded the maximum plant height, whereas Sonali Tara recorded the maximum number of branches, stem diameter and spread of plant. Among the pinching treatments, plants pinched at 30 days after planting were found to be the best for improving vegetative growth parameters.

Fatma (2017) conducted an experiment to evaluate pinching (0.0, 7, 10 and 13 cm) and potassium combinations on *calendula officinalis*. It was found that the best results were obtained with the application of pinching at 10 cm concerning vegetative parameters (plant height, branch number/plant, fresh and dry weights of foliage/plant, leaf number/plant and leaf area/plant) compared to other pinching treatments.

Nain *et al*. (2017) conducted an experiment at the orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hissar (Haryana) in African marigold. It was reported that plants pinched at 28 DAT with the widest spacing (40 x 40 cm) was found reduced plant height and increased number of branches and plant spread.

Palekar (2018) worked on marigold using different levels of pinching and nitrogen (T1 – no pinching + 75 kg N/ha, T2 – no pinching + 100 kg N/ha, T3-no pinching + 125 kg N/ha, T4-single pinching + 75 kg N/ha, T5-single pinching + 100 kg N/ha, T6-single pinching + 125 kg N/ha, T7-double pinching + 75 kg N/ha, T8-double pinching + 100 kg N/ha and T9-double pinching + 125 kg N/ha). It was observed that maximum stem diameter, primary and secondary branches/ plant were noted with the plants treated with double pinching + 125 kg N/ ha.

Khan *et al*. (2018) conducted an experiment on the effect of pinching on the growth and flower production of marigold and found that pinching resulted in an increased maximum number of branches, plant height and stem diameter.

Ahmade (2019) accessed the effects of pinching (single and double) and paclobutrazol at concentrations of 0, 10 and 20 mg/l in garland chrysanthemum. He concluded that twice pinching gave a significant reduction in the plant height, plant dry weight and increased the branch number.

Santi *et al*. (2020) conducted an experiment in marigold pots to assess the effects of different levels of pinching and paclobutrazol. It was observed that the quality of pinching and paclobutrazol plants decreased plant height and leaf area but increased plant dry matter.

Jena (2021) carried out an experiment on the effect of pinching on the growth and flowering of annual chrysanthemum. Different levels of pinching were taken and he found that under double pinching parameters like number of leaves and primary branches was observed to be maximum.

Amiri *et al*. (2021) studied the effect of pinching on the growth and yield of chrysanthemum cv. Snowball and observed that the pinching at 20 days resulted in the highest plant height, highest number of branches/plant, highest number of leaves/ plant and the highest leaf area.

2.2.1 Effect of pinching on flowering parameters

Arora and Khanna (1986) reported that pinching delayed flower production by 10 to 20 days over non-pinched plants in marigold.

Kumar (2011) worked on different levels of pinching (no pinching, 20 and 30 DAT) and nitrogen (0, 50, 100 and 150 kg/ ha) in calendula var. Golden Emperor and reported that pinching reduced the length of the flower stalk, flower diameter and maximum days of bud initiation and opening of the first floret.

Rathore *et al*. (2011) conducted an experiment in two successive years in the rabi season where different levels of pinching (no pinching and pinching), ethrel and paclobutrazol (100, 200, 300 and 400 ppm). It was found that pinching treatment significantly increased number of flowers per plant.

Khobragade *et al*. (2012) carried out an experiment on the effects of planting distance and pinching on growth, flowering and yield in China aster. It was determined that pinching delayed flowering.

Singh *et al*. (2015) carried out an experiment on marigold cv. Pusa Narangi Gainda by treating with single pinching (SP), double pinching (DP), SP + 1% nitrogen, SP + 3% nitrogen, DP + 2% nitrogen and DP + 30% nitrogen. It was discovered that double pinching + 2% nitrogen significantly increased the number and weight of flowers/plant.

Fatma (2017) conducted an experiment to evaluate pinching (0.0, 7, 10 and 13 cm) and potassium combinations on *Calendula officinalis*. It was found that the best results were obtained with the pinching at 10 cm concerning flower yield components (flower number/plant, flower fresh and dry weights/plant and carotenoids content) compared to other pinching treatments.

Palekar (2018) worked on marigold using different levels of pinching and nitrogen (T1 – no pinching + 75 kg N/ha, T2 – no pinching + 100 kg N/ha, T3- no pinching + 125 kg N/ha, T4-single pinching + 75 kg N/ha, T5-single pinching + 100 kg N/ha, T6-single pinching + 125 kg N/ha, T7-double pinching + 75 kg N/ha, T8-double pinching + 100 kg N/ha and T9-double pinching + 125 kg N/ha). It was observed that maximum weight of flower, number of petals/flower and longevity of flower were recorded with the plants treated with no pinching + 125 kg N/ha.

Khan *et al*. (2018) conducted an experiment on the effect of pinching on the flower production of marigold and found that pinching resulted in increased days to 50% flowering, flower diameter and the number of flowers/plant.

Jindal *et al*. (2018) conducted a field experiment on the effect of planting time and pinching on growth and quality in chrysanthemum cv. Ratlam Selection. They observed that later pinching (50 DAP) resulted in maximum flowering span.

Ahmade (2019) assessed the effects of pinching (single and double) and paclobutrazol at concentrations of 0, 10 and 20 mg/litre in garland chrysanthemum.

He concluded that twice pinching gave a significant increase the inflorescence diameter, period from planting to inflorescence bud formation, period to opening 50% of inflorescences and total number of inflorescences

Sathappan (2019) carried out a trial in marigold CV. Benz and Maxima Yellow were used to observe the effects of different chemicals on GA_3 @ 50, 100 and 150 ppm, NAA @ 50, 100 and 150 ppm, MH @ 250, 500 and 750 ppm, Alar @ 200, 400 and 600 ppm and pinching with untreated control. It was noted that the pinching delayed flowering.

Xin-Sheng *et al*. (2019) carried out an experiment on different varieties of chrysanthemum i.e, Suju 10, Suju 12, Suju 13, Ch1-44 and Ch5-13 and concluded that two-time pinching increases the value of crown width, flower number, flower diameter and fresh bio mass of flower.

Mounika *et al*. (2019) investigated the effect of pinching and growth regulators on floral parameters of chrysanthemum cv. Pusa Kesari with three levels of pinching i.e. no pinching, single pinching and double pinching and 5 levels of growth regulators i.e., GA_3 @ 100 ppm, GA_3 @ 200 ppm, triacontanol @ 50 ppm, triacontanol @ 100 ppm and water spray. It was observed that the minimum number of days taken for first flower bud appearance, days taken for 50% flowering, days taken for the first harvest of flowers. Among the floral parameters, single pinched plants sprayed with GA3 @ 200 ppm recorded the maximum flower stalk length and vase life.

Rajput *et al*. (2020) investigated the effects of various levels of pinching and spacing on African marigolds and observed that pinching at 50 days resulted in an increase in fresh and dry flower weight/ plant.

Hawa *et al*. (2021) conducted an experiment on the effect of planting time and pinching on the flower quality of the annual chrysanthemum. They noted that single pinching at 30 days after transplanting improved the weight of the flower, diameter of the fully opened flower, diameter of the flower disc and longevity of the intact flower as compared to control.

Jena (2021) carried out an experiment on the effect of pinching on the growth and flowering of annual chrysanthemum cv. Local. Different levels of pinching were taken and he found that under double pinching parameters like number of flowers/plant, number of flowers/plot and ha was observed to be maximum.

Rahman *et al*. (2021) conducted an experiment to find out the effect of pinching and organic manures on growth, flowering and yield of dahlia cv. Red Symphony. It is concluded that the treatment pinching 40 DAT + Poultry manure (3t/ha) followed by pinching 40 DAT + vermicompost (5t/ha) and pinching 40 DAT + FYM (10t/ha). It was observed that the maximum number of flower, flower diameter and flower span.

2.2.3 Effect of pinching on seed parameters

Phetpradap *et al*. (1994) conducted an experiment on hybrid dahlia to study the effect of hand pinching, and other chemical on seed production and observed that pinching reduced the spread of flowering and seed heads at approximately the same height above ground level because of the promotion of lateral branch length but did not increase seed yield.

Singh and Baboo (2003) conducted an experiment on the effects of time of pinching at 0, 10, 20 and 30 days after transplanting in chrysanthemum and reported that pinching at 20 DAT resulted in the maximum flower yield.

Naik *et al*. (2004) investigated the effects of pinching and chemical spray on growth, flowering and xanthophyll yield in African marigold. It was noted that the maximum flower yield was obtained due to pinching × CCC 1000 ppm, followed by pinching × DAP 2%, which were found to be the best treatment combinations during both the seasons respectively.

Rathore *et al*. (2011) conducted an experiment in two successive years in the rabi season where different levels of pinching (no pinching and pinching), ethrel and paclobutrazol (100, 200, 300 and 400 ppm). It was found that pinching treatment significantly increased the flower yield/ hectare.

Khobragade *et al*. (2012) carried out an experiment on the effects of planting distance and pinching on growth, flowering and yield in China aster. It was determined that the interaction of spacing and pinching produced a higher yield and was economically superior to wider spacing with un pinched plants.

Singh *et al*. (2015) carried out an experiment on marigold cv. Pusa Narangi Gainda by treating with single pinching (SP), double pinching (DP), SP + 1% nitrogen, SP + 3% nitrogen, DP + 2% nitrogen and DP + 30% nitrogen. It was discovered that foliar applications of double pinching + 2% nitrogen significantly increased the weight of seeds/plant and seed yield/m.

Salve *et al*. (2016) studied the effect of pinching on chrysanthemum cvs. Shubra, Heritage, Sonali Tara, Piwalirewadi and Pandharirewadi were tested at four levels of pinching and found Sonali Tara recorded the maximum flower yield/plant and ha.

Palekar (2018) worked on marigold using different levels of pinching and nitrogen (T_1 – no pinching + 75 kg N/ha, T_2 – no pinching + 100 kg N/ha, T_3-no pinching + 125 kg N/ha, T_4-single pinching + 75 kg N/ha, T_5-single pinching + 100 kg N/ha, T_6-single pinching + 125 kg N/ha, T_7-double pinching + 75 kg N/ha, T_8-double pinching + 100 kg N/ha and T_9-double pinching + 125 kg N/ha). It was observed that maximum flower seed yield/plant was noted with the plants treated with double pinching + 125 kg N/ha.

Nathan *et al*. (2019) conducted an experiment on the effect of pinching and foliar application of bio regulators on growth and flower yield in gomphrena. They used different combinations of pinching at 15,20 and 25 DAT and the foliar application of vermiwash, panchagavya, humic acid and seaweed extract. They found that the pinching at 15 days after transplanting along with Vermiwash @ 1,5 dilution foliar sprays significantly increased the seed yield.

Ahmade (2019) assessed the effects of pinching (single and double) and paclobutrazol at concentrations of 0, 10 and 20 mg/litre in garland chrysanthemum. He concluded that twice pinching gave a significantly increased weight of the seed.

Xin-sheng *et al*. (2019) carried out an experiment on different varieties of chrysanthemum i.e, Suju 10', ' Suju 12', ' Suju 13', ' Ch1-44' and ' Ch5-13' and concluded that two-time pinching increases the yield/plant and yield/unit area.

Amiri *et al*. (2021) studied the effect of pinching on the growth and yield of chrysanthemum cv. Snowball and observed that the pinching at 20 days resulted in the highest flower yield/ plant and the highest flower yield/plot

Chapter III

MATERIALS AND METHODS

The field experiment was conducted entitled "Effect of benzyl adenine and pinching on growth, flowering and seed yield in calendula and phlox”. The field trial was conducted at the vegetable Farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during 2021–22. The following sections discuss the experimental materials and methods used during the investigation.

3.1 Geographical location of the experimental site

The experiment site is situated in the direction of Varanasi Railway Station, roughly 10 kilometers away from it. The latitude and longitude are 25° 31' north and 82° 97 east, respectively. The mean sea level is 128.93 meters at this location latitude.

3.2 Climate and Soil

Varanasi has a humid subtropical climate with substantial temperature variations between summer and winter. Here, winters are associated with cloudy nights while summers are characterized by hot and dry winds. The third week of June through the end of September is when the monsoon season typically begins. An average year has 1110 mm of rainfall and 1552.2 mm of potential evapotranspiration. Maximum temperatures during the experiment ranged from 29.7°C to 42°C, while minimum temperatures ranged from 14°C to 20.9°C. While the experiment was being conducted, the highest maximum relative humidity was recorded in the month of January (98%) and the highest maximum minimum relative humidity was recorded in the month of April (30%).

Weekly data on various weather parameters prevailing during the experiment was recorded at Meteorological Observatory at Agriculture Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The meteorological data prevailed during experiment period is shown in the Table 3.1.

Table 3.1: Weekly meteorological data of Horticulture Research Farm, B.H.U., Varanasi (from November 2021 – April 2022).

Week number	Month and date	Rainfall (mm)	Temperature (^oC)		Relative humidity (%)		Sunshine (hrs.)	Evaporation (mm)
			Max.	Min.	Max.	Min.		
45	Nov 05-11	0.0	29.7	14.0	95	54	6.7	1.8
46	12-18	0.0	28.5	13.5	96	48	6.5	1.9
47	19-25	0.0	28.7	12.2	90	40	7.2	1.8
48	26-02	0.0	26.7	10.6	97	51	5.4	1.2
49	Dec 03-09	0.0	26.8	12.8	97	54	4.2	1.2
50	10-16	0.0	24.6	8.6	94	44	5.4	1.2
51	17-23	0.0	22.3	7.2	91	53	6.0	1.3
52	24-31	8.6	21.9	10.0	97	72	3.1	0.8
1	Jan 01-07	1.2	19.2	8.8	98	75	3.3	0.6
2	08-14	5.4	22.1	11.8	96	74	1.6	0.9
3	15-21	0.0	18.5	6.7	93	70	2.2	1.2
4	22-28	49.0	20.0	9.8	94	68	3.4	1.7
5	29-04	4.3	22.7	8.6	94	61	7.2	1.9
6	Feb 05-11	0.0	22.6	9.6	94	57	5.7	2.0
7	12-18	0.0	25.0	7.9	92	47	9.6	2.7
8	19-25	0.3	26.7	12.3	90	59	8.7	3.2
9	26-04	0.4	28.6	12.5	95	53	8.4	2.9
10	Mar 05-11	0.0	29.7	13.5	89	54	9.4	3.5
11	12-18	0.0	32.9	16.6	89	53	8.9	4.1
12	19-25	0.0	36.5	19.3	85	49	8.7	4.6
13	26-01	0.0	38.0	18.6	79	39	9.4	5.9
14	Apr 02-08	0.0	40.2	18.1	76	31	9.7	6.5
15	09-15	0.0	40.5	21.6	78	33	9.4	6.2
16	16-22	0.0	40.9	21.9	73	32	9.8	7.5
17	23-29	0.0	42.0	20.9	65	30	10.1	8.6
18	30-06	0.0	38.2	23.8	74	34	8.7	8.1

The soils at Varanasi come under entisols. The soil of experiment site was well drained alluvial loam with good water holding capacity and with good humus content. The pH of the experimental soil was 7.2. The soil characteristics were shown in Table 3.2.

Table 3.2: Mechanical, physical and chemical characteristics of the experimental soil.

Particular	References	Methods	Value (%)
Mechanical analysis			
Coarse sand	Bouyaucos, 1962	Bouyaucos Hydrometer	3.37
Fine sand			45.38
Silt			28.30
Clay			18.40
Chemical analysis			
Total nitrogen	Jackson, 1967	Modified Kjeldal's method	0.082
Total phosphorus	Jackson, 1967	Bicarbonate extractable P and development blue colour	0.075
Total potassium	Jackson, 1967	Neutral normal ammonium acetate	0.028
pH	Jackson,1967	1,2 Soil water suspension measured with glass electrode pH meter	7.2

3.3 Planting material

The planting material for the present investigation comprised of seeds of *Calendula officinalis* and *Phlox durummodii* which were sown in nursery beds to raise seedlings.

3.4 Nursery bed preparation

The seed bed of 3.6×1.0 m^2 size was prepared by digging the soil and mixing well rotten farmyard manure (FYM) at 8 kg/m^2 and raising the level of beds to about 15 cm. The seeds were sown during October month of 2021. Light irrigation was provided to enhance the germination of seeds. To maintain proper moisture, the seed bed were frequently irrigated by watering can fitted with fine nozzle. The seed bed was kept free from weeds by regular hand weeding. The seedlings were ready for transplanting in 30 days.

3.5 Cultivation practices

3.5.1 Field preparation

Field preparation was done with repeated ploughing and harrowing to obtain fine tilth. All weeds were removed manually from the field. During last ploughing, well rotten FYM at 5kg/m^2 Nitrogen at 150 kg/ha, phosphorus and potassium each at 80 kg/ha were applied. Full amount of P and K was incorporated in the soil during last ploughing. Nitrogen doses were split into two equal doses 75 kg N/ha each and was broadcasted after one month of transplanting and at the time of bud initiation. After this the required area of land marked and the field were made according to the layout of plan shown in the Fig. 3.1.

3.5.2 Transplanting of seedlings

Healthy seedlings having uniform growth with 3-4 leaf of 30 days old were selected for transplanting. The uprooted seedlings were immediately transplanted to the main field during December, 2021 at a spacing of 60 cm between row to row and 50 cm between plant to plant. Transplanting was done in the evening hours to avoid exposure to sunlight and to allow better establishment in cool hours of the night.

3.5.3 Fertilizer application

Broadcasting of nitrogeneous fertilizer (as Urea) at the rate of 100 Kg/ha was done at 50 days after transplanting.

3.5.4 Weeding and irrigation

First irrigation was given just after transplanting with the help of a watering cane and subsequent irrigations were given every day for 3-4 days till the establishment of the seedlings. After establishment irrigation was given with the flooding method at weekly interval. Manual weeding was performed periodically to keep the field weed-free. First weeding was done during mid December 2021, manually then subsequent weeding was done till the plants attain full spread to suppress the weeds.

3.5.5 Plant protection measures

Aphid and whitefly were major insect infestations seen on the experimental plots of both crops' calendula and phlox. To control aphids and whitefly, Dimethoate 30% Ec at the rate of 0.15% was sprayed as per requirement. Wilting and collar rot were major diseases mainly seen in the experimental plot of phlox. To control the disease fungicide SAAF (12% carbendazim + 63% WP mancozeb) was sprayed as per requirement at the rate of 0.001% (1g/l).

3.6 Experiment details

3.6.1 Experiment no. 1: Effect of BA and pinching on growth, flowering and seed yield attribute in calendula.

1. Crops: Calendula (*Calendula officinals*)
2. Plant growth regulator: Benzyl adenine (Control, 50, 100, 150, 200, 250 and 300)
3. Level of pinching: 2 (pinching and no pinching)
4. Design of experiment: Randomized Block Design
5. Factors: 2 (Plant growth regulators and pinching)
6. Number of treatments combinations: 14
7. Number of replications: 3
8. Plot size: 2.4 x 2 m^2
9. Planting distance: 60×50 cm

3.6.2 Experiment no. 2: Effect of BA and pinching on growth, flowering and seed yield attribute in phlox.

1. Crops: Phlox (*Phlox drummondii*)
2. Plant growth regulator: Benzyl adenine (Control, 50, 100, 150, 200, 250 and 300)
3. Level of pinching: 2 (pinching and no pinching)
4. Design of experiment: Randomized Block Design
5. Factors: 2 (Plant growth regulators and pinching)
6. Number of treatments combinations: 14
7. Number of replications: 3
8. Plot size: 2.4 x 2 m^2
9. Planting distance: 60×50 cm

Table no 3.3 Treatments Details and notations

S. No.	Name of treatments	Notation
1.	Control (Distilled water)	T_1
2.	BA 50 ppm	T_2
3.	BA 100 ppm	T_3
4.	BA 150 ppm	T_4
5.	BA 200 ppm	T_5
6.	BA 250 ppm	T_6
7.	BA 300 ppm	T_7
8.	Pinching + Control	T_8
9.	Pinching + BA 50 ppm	T_9
10.	Pinching + BA 100 ppm	T_{10}
11.	Pinching + BA 150 ppm	T_{11}
12.	Pinching + BA 200 ppm	T_{12}
13.	Pinching + BA 250 ppm	T_{13}
14.	Pinching + BA 300 ppm	T_{14}

Figure 3.1: Layout of experimental field

R_1		R_2		R_3
T_3		T_{11}		T_{12}
T_{12}		T_{10}		T_4
T_6		T_{13}		T_5
T_7	P	T_{14}	P	T_{11}
T_5		T_4		T_7
T_{11}	A	T_3	A	T_1
T_8		T_1		T_{13}
T_1	T	T_5	T	T_{14}
T_9		T_8		T_{10}
T_{14}	H	T_2	H	T_6
T_4		T_9		T_3
T_{13}		T_6		T_2
T_2		T_7		T_8
T_{10}		T_{12}		T_9

3.7 Growth regulator solutions

There were total of 14 treatments including control (Distilled water). Different concentrations of BA were prepared and sprayed on individual plant with the help of hand operated sprayer till run-off stage.

3.7.1 Preparation of BA solution

Benzyl adenine is an alcohol soluble. So benzyl adenine was dissolved with 1 ml of alcohol. Distilled water of 200 ml measured and with mix alcohol solution.

3.8 Observations recorded for growth, flowering and seed parameters in calendula and phlox

Different Parameters were recorded in calendula and phlox on the basis of growth, flowering and seed yield attribute.

3.8.1 Growth parameters

1. Plant height (cm)

The height of the plants was recorded from the base of the plant to the tip of the apical flower of the longest shoot at 60 days after transplanting (DAT) and 90 DAT. Average was worked out and recorded in cm.

2. Plant spread (cm)

The average of the distance between the outermost side leaves in the east to west direction and the distance between the outermost side leaves in the north to south direction was recorded at 60 DAT and 90 DAT. Meter scale was used to measure the distance in cm and average was worked out.

3. Number of primary branches/plant

Numbers of primary branches are counted at 60 DAT and 90 DAT and expressed in numbers.

4. Number of secondary branches/plant

All the branches arising from primary branches are secondary branches and were counted in an individual plant and their average value was recorded 90 DAT.

5. Number of leaves per plant

Number of leaves was counted for each tagged plant at 90 days and their average was noted

6. Fresh weight of leaves (g)

The fresh weight of the leaves was measured on a common electric balance at peak flowering stage and it is expressed in gram (g).

7. Dry weight of leaves (g)

The dry weight of the leaves was measured on a common electric balance after drying the sample in hot air oven till the sample attains a constant weight and it is expressed in gram (g).

8. Stem diameter (mm)

Stem diameter was measured using by vernier caliper from the ground level and expressed in mili meter (mm).

9. Leaf area (cm^2)

Leaf area was recorded from per plants of each treatment and was then measured by using leaf area meter in cm^2.

10. Leaf area index

Leaf area index is calculated by given formula,

$$\text{Leaf area index} = \frac{\text{Leaf area (cm}^2\text{)} \times \text{No. of leaves per plant}}{\text{Plant spacing (60} \times \text{50 cm)}}$$

3.8.2 Flowering parameters

All the observations on growth characters viz., days to bud initiation, days to flowering, bud diameter, peduncle length, flower diameter, number of flowers per plant, fresh weight of flower, dry weight of flower and flowering withering were recorded during the course of investigation. The details of technique followed for recording the observations were as follows.

1. Days to flower bud initiation (Days)

Number of days was counted from date of transplanting to the date of first visible flower bud formation and average was calculated.

2. Days to flower initiation (Days)

Number of days was counted from date of transplanting to the colour showing stage of first bud.

3. Bud diameter (mm)

Bud diameter of five fully developed bud of an individual plant was calculated using digital vernier calipers and average was computed.

4. Flower diameter (mm)

Flower diameter was measured at the point of maximum breadth using digital vernier calipers of three randomly selected flower of an individual plant and average was computed.

5. Peduncle length (cm)

Peduncle length was calculated from the base of flower to the branching or node and was expressed in cm.

6. Number of flowers per plant

The total number of flowers was counted at full bloom stage from each tagged plant and their average was calculated.

7. Flower fresh weight (g)

Ten flowers were randomly selected from each replication and their total weight was recorded on common electric balance in gram (g).

8. Flower dry weight (g)

The dry weight of ten flowers which were randomly selected from each replication was weighed on a common electric balance after drying the sample in hot air oven till the sample attains a constant weight and it is expressed in gram (g).

9. Days to flower withering (Days)

Number of days was counted from the date of transplanting to the stage when first flower withers.

3.8.3 Seed yield parameters

1. Days to seed ripening (Days)

Number of days were counted from date of transplanting to the ripening of seed and expressed in days.

2. Number of seeds/flower

Number of seeds were counted in an individual flower and expressed in numbers.

3. Seed yield/plant (g)

Five flowers were randomly selected from each plant for harvesting of seeds and weighed on a common electric balance in gram.

4. Seed yield/m^2 (g)

Five flowers were randomly selected from each plant for harvesting of seeds and weighed on a common electric balance in grams and yield was calculated per m^2.

5. Test weight (g)

Weight of 1000 seed from each tagged plants were taken measured using common electric balance and average was calculated, expressed in gram (g).

3.9 Statistical analysis

The data recorded for growth, flowering and seed yield attributed in both calendula and phlox during the course of investigation were statistically analyzed by using Randomized Block Design for analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1985). The significance of the treatment was tested by “F” test. Critical difference (CD) at 5% level of significance was worked out to judge the significant difference between two means. The standard error of difference was given in each case for significant treatment effect.

The analysis of variance table for two factors *i.e.,* Treatment with ‘t’ levels and pinching with ‘p’ level with ‘r’ replications tried in RBD will be as follows,

Table 3.4 Analysis of variance

Source of variation	Degree of freedom	Sum of squares	Mean sum of square	F cal	F tab (5%)
Replication	(r-1)	SSr	MSr	MSr/MSe	
Treatment	(t-1)	SSt	MSt	MSt/MSe	
Error	(r-1) (t-1)	SSe	MSe		
Total	(rt-1)	TSS			

In order to compare the means of different treatments, the C.D. was calculated using the following formula.

C.D. = SE (d) × t 0.05 error degree of freedom

Where, SE (d) is the standard error of difference of means which were calculated using following formula.

SE (d) ± = $\sqrt{}$ 2MS (E) ÷r

SE (m) ± = S÷$\sqrt{n}$

Where,

SEM = standard error of mean

s = sample standard deviation

n = size (number of observations) of the sample.

Chapter IV

EXPERIMENTAL FINDINGS

The present investigation on "Effect of SNP in the growth, flowering and seed yield in nasturtium and California poppy was conducted at Horticulture Research Farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) during 2021 to 2022.

4.1 Experiment no. 1: Effect of BA and pinching on growth, flowering and seed yield parameters in calendula.

4.1.1 Effect of BA and pinching on vegetative parameters

4.1.1.1 Plant height at 60 DAT

The data regarding effect of BA, pinching and their interactions on plant height at 60 DAT is presented in Table 4.1 and Fig 4.1. Plant height at 60 DAT in calendula is significantly influenced due to different levels of pinching and BA but their interactions failed to exert any significant result. Treatment no pinching (24.10 cm) resulted in maximum plant height which was significant to treatment pinching. Among various doses of BA, maximum plant height (24.03 cm) was recorded with BA 150 ppm followed by BA 250 ppm and significant to all other treatments. Minimum plant height was observed with treatment control.

4.1.1.2 Plant height at 90 DAT

It is depicted in Table 4.1 and Fig 4.1 that different levels of pinching, BA and their interactions significantly influenced on plant height at 90 DAT in calendula. Treatment no pinching (47.24) recorded maximum plant height which was significant to treatment pinching. Among various levels of BA, maximum plant height (50.08 cm) was observed with BA 150 ppm which was at par with BA 250 ppm and significant to all other treatments. Interaction of no pinching with BA 250 ppm recorded maximum plant height (54.68 cm) which was at par with interaction of BA 150 ppm× pinching and significant to all other interactions. While minimum plant height (38.42 cm) was found with interaction of BA 50 ppm × pinching.

Table 4.1: Effect of BA and pinching on plant height at 60 & 90 DAT in calendula

Treatment	**Plant height at 60 DAT (cm)**	**Plant height at 90 DAT (cm)**
No pinching	24.10	47.24
Pinching	18.61	43.91
C.D. at 5%	0.87	1.78
Control	19.70	41.84
BA 50 ppm	19.76	42.07
BA 100 ppm	21.44	44.58
BA 150 ppm	24.03	50.08
BA 200 ppm	21.68	43.70
BA 250 ppm	22.41	49.67
BA 300 ppm	20.47	46.13
C.D. at 5%	1.63	3.33
Interaction (T×P)		
Control × No pinching	22.22	42.85
BA 50 ppm × No pinching	22.14	45.60
BA 100 ppm × No pinching	24.21	43.17
BA 150 ppm × No pinching	26.52	48.76
BA 200 ppm × No pinching	24.70	46.27
BA 250 ppm × No pinching	26.35	54.68
BA 300 ppm × No pinching	22.53	47.32
Control × Pinching	17.18	40.82
BA 50 ppm × Pinching	17.37	38.42
BA 100 ppm × Pinching	18.67	45.98
BA 150 ppm × Pinching	21.55	51.41
BA 200 ppm × Pinching	18.66	41.13
BA 250 ppm × Pinching	18.47	44.66
BA 300 ppm × Pinching	18.40	44.94
C.D. at 5%	NS	4.72

4.1.1.3 Number of primary branches per plant at 60 DAT

The data in relation to number of primary branches per plant AT 60 DAT is presented in Table 4.2 and Fig. 4.2 which reveals that pinching, BA and their interactions had significant influence on number of primary branches per plant. Maximum number of primary branches per plant was recorded with pinched plants (8.90) which was significant to unpinched plants. As regards the effects of benzyl adenine application, the maximum number of primary branches per plant (10.94) was produced in plants treated with treatment BA 250 ppm (10.94) followed by BA 300 ppm and significant to all other treatments. Minimum number of primary branches per plant was recorded with treatment control. Among various interaction between pinching and BA, maximum number of primary branches (11.72) was recorded with interaction of BA 250 ppm × pinching followed by interaction of BA 250 ppm × no pinching and significant to all other interactions. Interaction of control × pinching resulted in minimum number of primary branches per plant.

4.1.1.4 Number of primary branches per plant at 90 days

The data pertaining to no. of primary branches at 90 days as significantly influence by different levels of BA, pinching and their interactions is given in Table 4.2 and Fig.4.2. Treatment pinching (11.21) showed maximum number of primary branches which was significant to all other treatment no pinching. Among various foliar spray of BA, maximum number of primary branches was reported with treatment BA 250 ppm (11.93) followed by treatments BA 300 ppm, BA 200, BA 150 ppm and found significant all other treatments. Whereas minimum number of primary branches was registered with control (9.27). Maximum number of primary branches per plant was recorded with the interaction of BA 250 ppm × pinching (12.94) followed by interactions of BA 150 ppm × pinching, BA 300 ppm × pinching, BA 50 ppm × pinching and significant to all other interaction treatments. Minimum number of primary branches per plant was found with interaction of BA 50 ppm × no pinching.

Table 4.2: Effect of BA and pinching on number of primary branches/plant at 60 & 90 DAT and number of secondary branches/plant in calendula

Treatment	**No. of primary branches/plant at 60 DAT**	**No. of primary branches/plant at 90 DAT**	**Number of secondary branches/plant**
No pinching	8.81	9.35	53.68
Pinching	8.90	11.21	53.77
C.D. at 5%	0.008	0.32	NS
Control	7.54	9.27	43.00
BA 50 ppm	8.60	9.73	53.97
BA 100 ppm	8.46	10.17	53.94
BA 150 ppm	8.48	10.61	64.11
BA 200 ppm	8.58	9.49	49.97
BA 250 ppm	10.94	11.93	57.64
BA 300 ppm	9.38	10.75	53.46
C.D. at 5%	0.01	0.60	0.73
Interaction			
Control × No pinching	8.64	8.71	46.39
BA 50 ppm × No pinching	8.94	8.33	59.39
BA 100 ppm × No pinching	9.11	10.00	57.83
BA 150 ppm × No pinching	7.64	9.22	61.16
BA 200 ppm × No pinching	8.05	8.53	49.94
BA 250 ppm × No pinching	10.16	10.92	52.50
BA 300 ppm × No pinching	9.10	9.72	48.55
Control × Pinching	6.43	9.83	39.61
BA 50 ppm × Pinching	8.26	11.13	48.55
BA 100 ppm × Pinching	7.80	10.33	50.05
BA 150 ppm × Pinching	9.32	12.00	67.05
BA 200 ppm × Pinching	9.11	10.44	50.00
BA 250 ppm × Pinching	11.72	12.94	62.78
BA 300 ppm × Pinching	9.66	11.78	58.36
C.D. at 5%	0.01	0.85	1.04

Fig. 4.1 **Effect of BA and pinching on plant height at 60 and 90 DAT in calendula.**

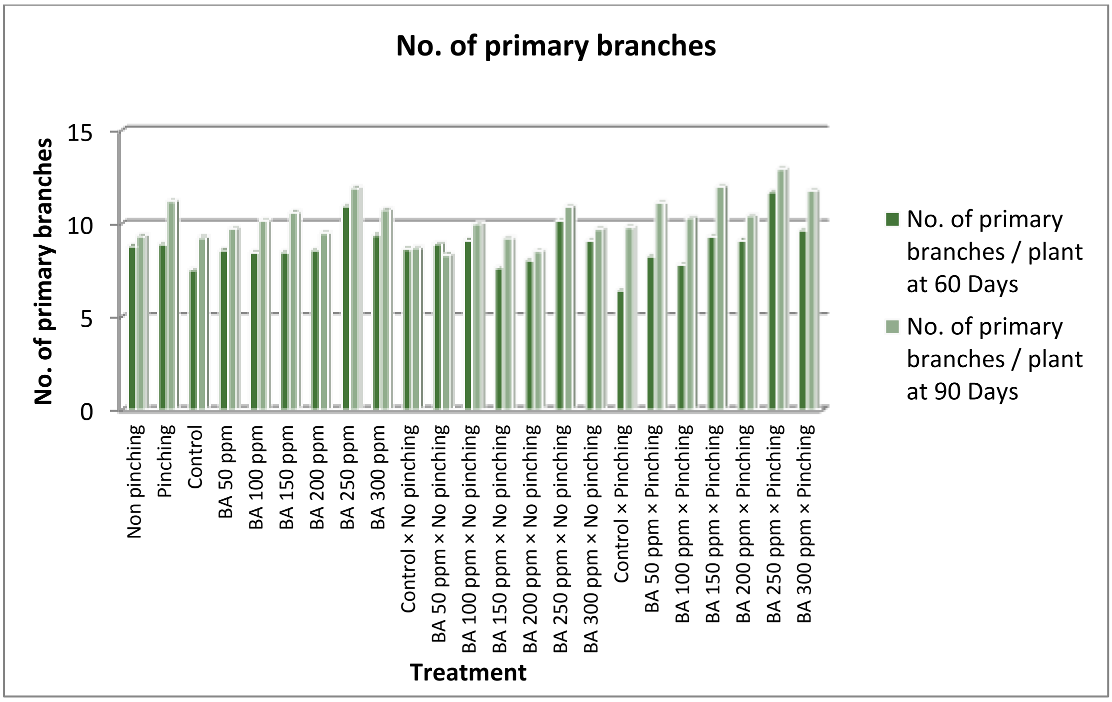

Fig. 4.2 **Effect of BA and pinching on number of primary branches/plant at 60 and 90 DAT in calendula.**

4.1.1.5 Number of secondary branches per plant

The number of secondary branches per plant was significantly influenced by different concentrations of BA and its interaction with pinching (Table 4.2 and Fig 4.3). However, pinching treatment alone failed to exert any significant variation. The maximum number of secondary branches per plant (64.11) was recorded with treatment BA 150 ppm which was significant to all other BA treatments. Whereas, minimum number of secondary branches per plant was recorded with control. Among various interactions, Interaction of BA 150 ppm × pinching resulted maximum number of secondary branches per plant (67.05) followed by interactions of BA 250 ppm × pinching, BA 150 ppm × no pinching, BA 50 ppm × no pinching and significant to the other interactions. The combination treatment of control × pinching and control× no pinching recorded minimum number of secondary branches per plant.

4.1.1.6 Plant spread at 60 DAT

At 60 and 90 DAT the results revealed that BA, pinching and their interaction had a significant effect on plant spread (Table 4.3 and Fig. 4.4). Treatment pinching showed maximum plant spread (43.01cm) which was significant to no pinching (41.61 cm). Out of various levels of BA treatments, BA 150 ppm (46.92 cm) recorded maximum plant spread which was at par with BA 100 ppm and BA 250 ppm and significant to all other BA treatments. Minimum plant spread was observed with control. Among the interaction treatments, interaction of BA 100 ppm × pinching recorded significantly maximum plant spread (48.01) which was statistically at par with interactions of BA 150 ppm × no pinching, BA 150 ppm × no pinching and significant to all other interactions. Minimum plant spread was recorded with interaction of BA 200 ppm × pinching.

4.1.1.7 Plant spread at 90 DAT

The data on plant spread at 90 DAT revealed that BA, pinching and their interactions had a significant effect on spread in calendula. Plant spread was recorded maximum with pinched plants (63.72 cm) and minimum unpinched plants (58.39 cm).

Among various doses of BA treatments, BA 300 ppm (65.29 cm) resulted maximum plant spread which was significantly at par with treatments BA 150 ppm, BA 250 ppm and significant to all other treatments. Interaction of BA 200 ppm × pinching (66.28 cm) registered maximum plant spread which was at par with interactions of BA 300 ppm × pinching, BA 250 ppm × pinching, BA 150 ppm × pinching and BA 300 ppm × no pinching. While, minimum plant spread was observed with interaction of BA 50 ppm × no pinching.

4.1.1.8 Stem diameter

The data pertaining to influence of BA, pinching and their interactions on diameter of stem have been presented in Table 4.3 and graphically depicted in Fig 4.5 which suggests that stem diameter was significantly influenced due to various levels of BA, pinching and their interactions. The stem diameter of pinched plants (20.09 mm) was found maximum followed by unpinched plants (14.81mm). However, among different treatment of BA, BA 200 ppm (18.60 mm) had the maximum stem diameter which was at par with treatments BA 150 ppm, BA 300 ppm, BA 250 ppm and significant to all other treatments. Maximum stem diameter was found with interaction of BA 200 ppm × pinching (22.36 mm) which was at par with interactions of BA 300 ppm × pinching, BA 150 ppm × pinching and significant to all other interaction treatments. While, Minimum stem diameter was recorded with interaction of BA 100 ppm × no pinching.

Table 4.3: Effect of BA and pinching on plant spread at 60 & 90 DAT and stem diameter in calendula

Treatment	Plant spread at 60 DAT (cm)	Plant spread at 90 DAT (cm)	Stem diameter (mm)
No pinching	41.61	58.39	14.81
Pinching	43.01	63.72	20.09
C.D. at 5%	0.45	1.91	0.64
Control	39.70	57.23	16.43
BA 50 ppm	40.22	57.56	16.71
BA 100 ppm	44.52	60.94	17.10
BA 150 ppm	46.92	62.32	18.18
BA 200 ppm	40.04	61.96	18.60
BA 250 ppm	43.88	62.11	17.51
BA 300 ppm	40.89	65.29	17.63
C.D. at 5%	0.84	1.02	1.20
Interaction (T×P)			
Control × No pinching	39.51	56.97	14.70
BA 50 ppm × No pinching	40.43	52.36	14.46
BA 100 ppm × No pinching	41.03	56.83	14.37
BA 150 ppm × No pinching	47.38	60.80	15.59
BA 200 ppm × No pinching	40.81	57.64	14.83
BA 250 ppm × No pinching	42.71	59.08	15.32
BA 300 ppm × No pinching	39.42	65.05	14.38
Control × Pinching	39.88	57.50	18.15
BA 50 ppm × Pinching	40.00	62.75	18.96
BA 100 ppm × Pinching	48.01	65.05	19.83
BA 150 ppm × pinching	46.47	63.83	20.76
BA 200 ppm × Pinching	39.27	66.28	22.36
BA 250 ppm × Pinching	45.05	65.14	19.70
BA 300 ppm × Pinching	42.36	65.53	20.87
C.D. at 5%	1.19	2.70	1.69

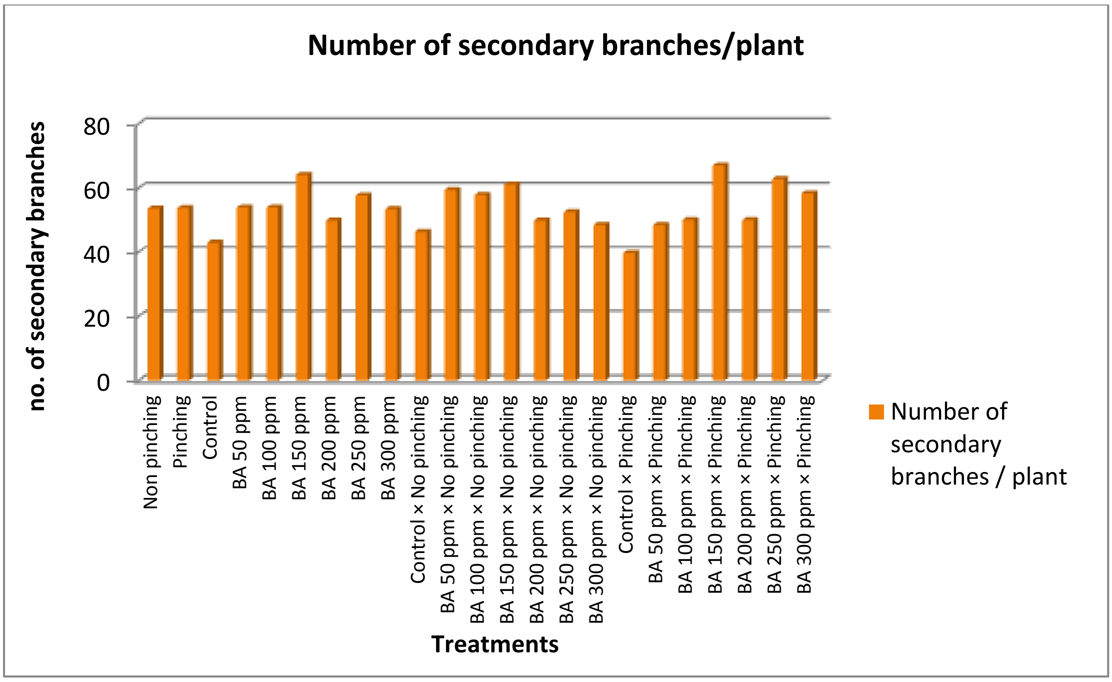

Fig. 4.3 **Effect of BA and pinching on number of secondary branches/plant in calendula.**

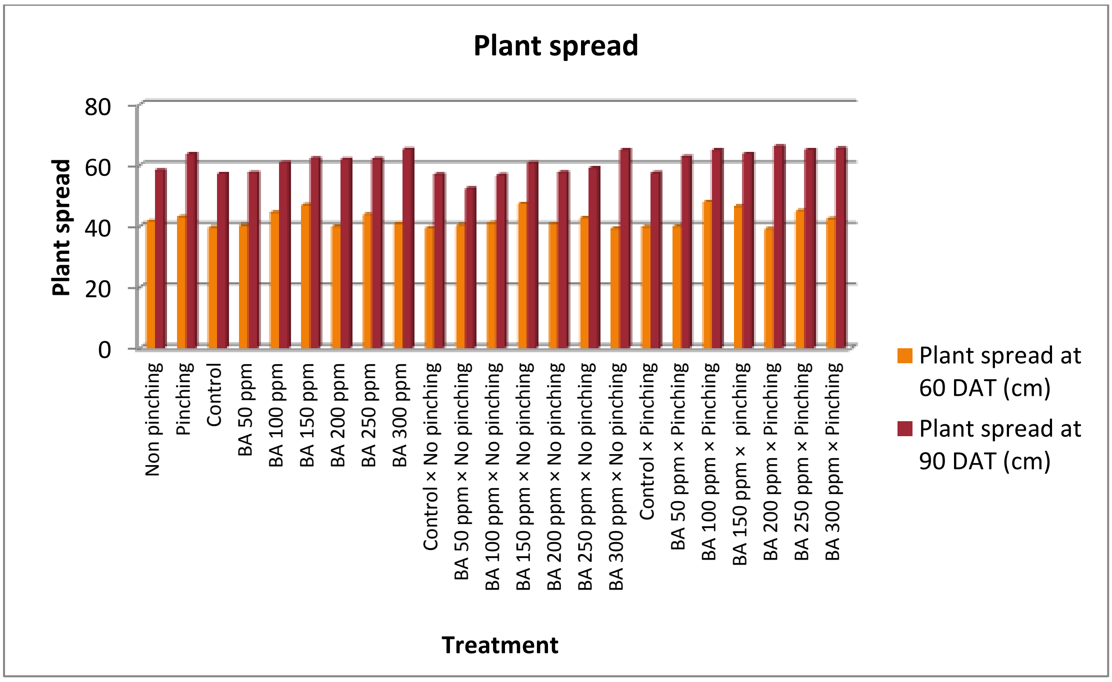

Fig. 4.4 Effect of BA and pinching on plant spread at 60 & 90 DAT in calendula.

4.1.1.9 Fresh weight of leaves

Results showed that BA and pinching had a significant effect on fresh weight of leaves but their interactions failed to generate any significant influence on fresh weight of leaves (Table 4.4 and Fig 4.6). Pinching resulted in maximum fresh weight of leaf (6.04 g) which was significantly higher than no pinching. Among various levels of BA, maximum fresh weight of leaf was recorded with BA 150 ppm (6.60 g) which was statistically at par with BA 200 ppm, BA 250 ppm and significant to all other treatments.

4.1.1.10 Dry weight of leaves

The data pertaining to dry weight of leaves as significantly influenced due to pinching, BA and their interactions is presented in Table 4.4 and Fig 4.6. Treatment pinching (0.91 g) recorded maximum dry weight which was statistically significant to no pinching (0.76 g). Maximum dry weight of leaves was observed with control which was statistically at par with BA 250 ppm and significant to all other treatments. Among various combination treatments, maximum dry weight was observed with combination of control × pinching (1.13 g) which was at par with interactions of BA 200 ppm × pinching, BA 250 ppm × no pinching and significant to all other combination treatments. However, minimum dry weight of leaves was recorded with interaction of BA 300 ppm × no pinching.

4.1.1.11 Leaf area

The data regarding leaf area is presented in Table 4.5 and illustrated in Fig. 4.7 indicated that various levels of BA, pinching and their interactions resulted significant influence on leaf area in calendula. Maximum leaf area (107.02 cm^2) was observed with treatment pinching which was significantly higher than no pinching treatment. Among various doses of BA, recorded maximum leaf area was observed with treatment BA 150 ppm (117.00 cm^2) which was at par with BA 200 ppm and significant to all other treatments. However, minimum leaf area was found with control.

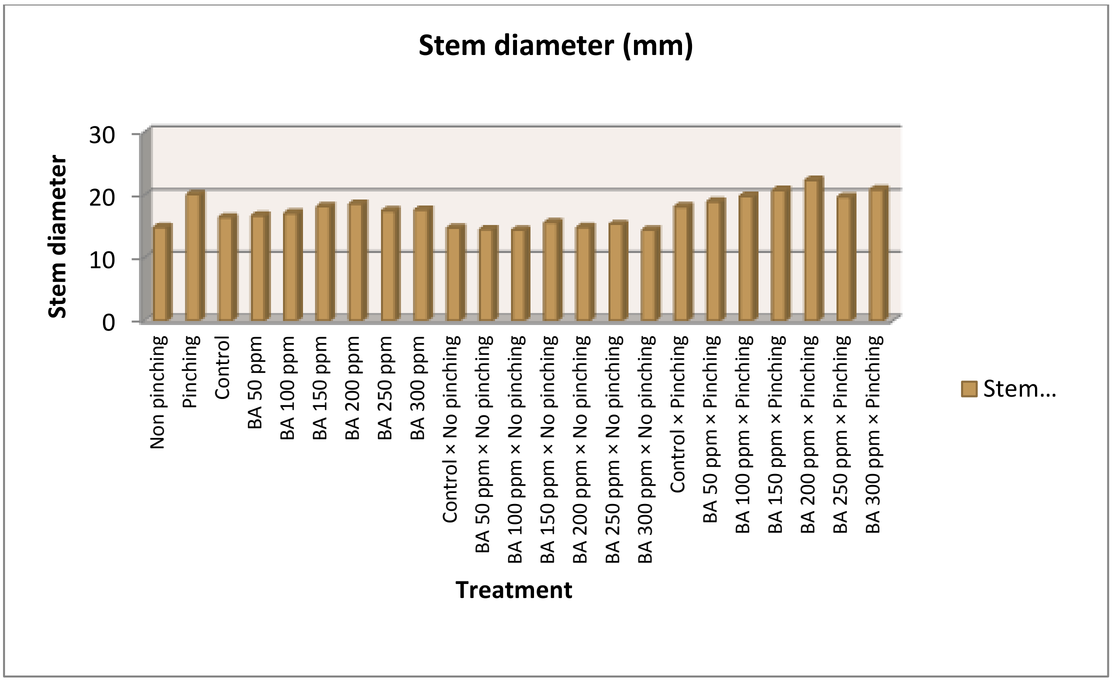

Fig. 4.5 Effect of BA and pinching on stem diameter in calendula

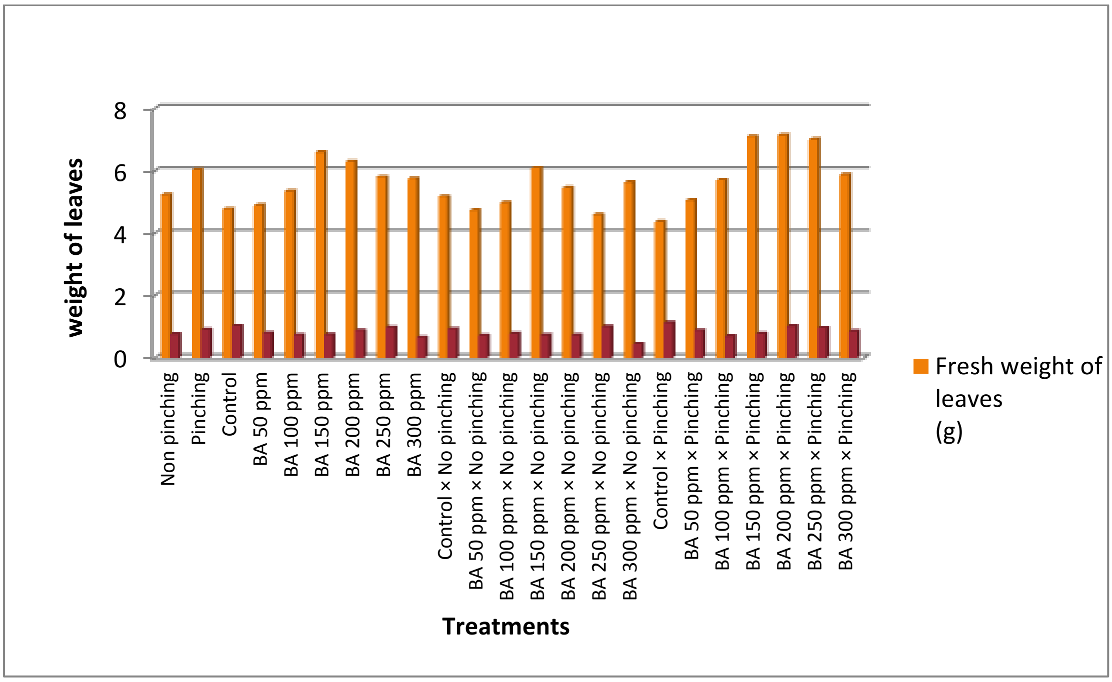

Fig. 4.6 Effect of BA and pinching on fresh and dry weight of leaves in calendula

Table 4.4: Effect of BA and pinching on fresh and dry weight of leaves in calendula

Treatment	Fresh weight of leaves (g)	Dry weight of leaves(g)
No pinching	5.24	0.76
Pinching	6.04	0.91
C.D. at 5%	0.55	0.04
Control	4.78	1.03
BA 50 ppm	4.90	0.80
BA 100 ppm	5.35	0.74
BA 150 ppm	6.60	0.75
BA 200 ppm	6.31	0.88
BA 250 ppm	5.81	0.98
BA 300 ppm	5.76	0.66
C.D. at 5%	1.03	0.07
Interaction (T×P)		
Control × No pinching	5.18	0.93
BA 50 ppm × No pinching	4.74	0.72
BA 100 ppm × No pinching	4.98	0.78
BA 150 ppm × No pinching	6.10	0.73
BA 200 ppm × No pinching	5.46	0.73
BA 250 ppm × No pinching	4.60	1.00
BA 300 ppm × No pinching	5.64	0.45
Control × Pinching	4.37	1.13
BA 50 ppm × Pinching	5.06	0.88
BA 100 ppm × Pinching	5.71	0.70
BA 150 ppm × Pinching	7.11	0.78
BA 200 ppm × Pinching	7.15	1.02
BA 250 ppm × Pinching	7.02	0.96
BA 300 ppm × Pinching	5.88	0.86
C.D. at 5%	NS	0.11

Interaction of BA 200 ppm × pinching resulted maximum leaf area (128.34 cm^2) which was at par with interactions of BA 150 ppm × no pinching, BA 50 ppm × pinching and significant to all interaction treatments. Minimum leaf area was observed with interaction of BA × no pinching.

4.1.1.12 Leaf area index

Table 4.5 shows the result of the leaf area index as significantly influenced by BA and pinching. However, interaction of BA with pinching failed to exert any significant influence on leaf area index in calendula. Treatment pinching (2.53) resulted maximum leaf area index which was significant to treatment no pinching. Among various BA treatments, treatment BA 150 ppm recorded significantly higher leaf area index (2.64) which was at par with BA 300 ppm, BA 250 ppm and was significant to all other treatments. Minimum leaf area index was found with control.

4.1.1.13 Number of leaves/plant

It is apparent from the data pertaining to number of leaves per plant provided in Table 4.6 and Fig. 4.8. Different levels of pinching and BA led to a significant variation in the number of leaves per plant. However, interaction of pinching with BA failed to show any significant influence on number of leaves per plant. Treatment pinching (711.83) recorded maximum number of leaves per plant which was significant to treatment no pinching. Among various benzyl adenine treatments, maximum number of leaves per plant (754.77) was noted BA 200 ppm which was at par with treatments BA 250 ppm, BA 300 ppm and significant to all other treatments. Minimum number of leaves per plant was observed with control.

Table 4.5: Effect of BA and pinching on leaf area index and leaf area in calendula.

Treatment	**Leaf area index**	**Leaf area (cm^2)**
No pinching	1.90	97.99
Pinching	2.53	107.02
C.D. at 5%	0.21	5.06
Control	1.89	91.68
BA 50ppm	1.92	103.49
BA 100ppm	2.08	95.11
BA 150 ppm	2.64	117.00
BA 200ppm	2.20	114.29
BA 250ppm	2.30	97.77
BA 300ppm	2.49	98.20
C.D. at 5%	0.39	9.47
Interaction (T×P)		
Control × No pinching	1.86	93.57
BA 50 ppm × No pinching	1.55	93.34
BA 100 ppm × No pinching	1.65	91.19
BA 150 ppm × No pinching	2.56	117.42
BA 200 ppm × No pinching	1.69	100.23
BA 250 ppm × No pinching	2.03	95.30
BA 300 ppm × No pinching	1.94	94.91
Control × Pinching	1.91	89.80
BA 50 ppm × Pinching	2.29	113.63
BA 100 ppm × Pinching	2.51	99.03
BA 150 ppm × Pinching	2.72	116.59
BA 200 ppm × Pinching	2.70	128.34
BA 250 ppm × Pinching	2.56	100.23
BA 300 ppm × Pinching	3.04	101.49
C.D. at 5%	NS	13.40

Table 4.6: Effect of BA and pinching on number of leaves/plant in calendula

Treatment	**Number of leaves/plant**
No pinching	579.02
Pinching	711.83
C.D. at 5%	49.61
Control	569.19
BA 50 ppm	595.33
BA 100 ppm	616.36
BA 150 ppm	601.83
BA 200 ppm	754.77
BA 250 ppm	702.69
BA 300 ppm	677.81
C.D. at 5%	92.81
Interaction (T×P)	
Control × No pinching	507.39
BA 50 ppm × No pinching	531.72
BA 100 ppm × No pinching	598.50
BA 150 ppm × No pinching	510.78
BA 200 ppm × No pinching	610.94
BA 250 ppm × No pinching	638.50
BA 300 ppm × No pinching	655.33
Control × Pinching	631.00
BA 50 ppm × Pinching	658.94
BA 100 ppm × Pinching	634.22
BA 150 ppm × Pinching	692.89
BA 200 ppm × Pinching	898.59
BA 250 ppm × Pinching	766.89
BA 300 ppm × Pinching	700.28
C.D. at 5%	NS

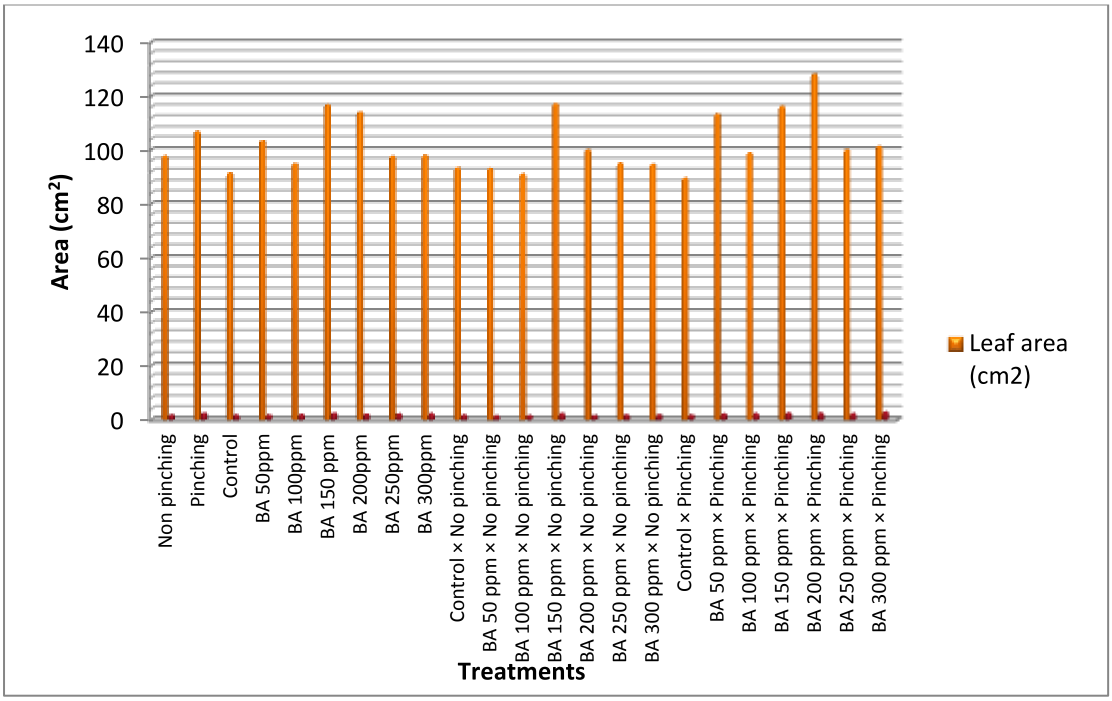

Fig. 4.7 Effect of BA and pinching on leaf area in calendula.

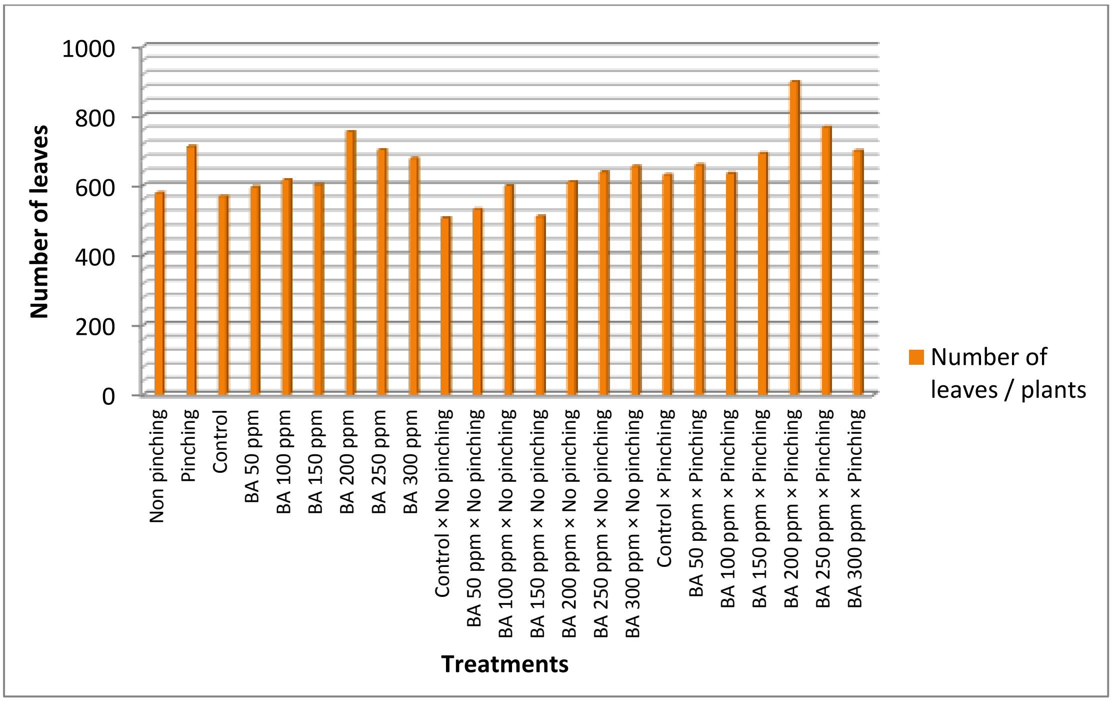

Fig. 4.8 Effect of BA and pinching on number of leaves/plant in calendula.

4.1.2 Effect of BA and pinching on flowering parameters in calendula

4.1.2.1 Days to bud initiation

The data pertaining to days to bud initiation as significantly influenced due to BA, pinching and their interactions is presented in Table 4.7 and depicted in Fig. 4.9. Maximum days to bud initiation was found with pinching (60.02 days) which was significant to no pinching (46.39 days). Maximum days to bud initiation was recorded with BA 250 ppm (55.30 days) which was at par with BA 50 ppm, BA 100 ppm and was significant to all other treatments. Minimum days to bud initiation was reported with control. Combination of BA × pinching revealed that maximum days to bud initiation was reported with interaction of BA 250 ppm × pinching (63.89 days) which was at par with interaction of BA 50 ppm × pinching and significant to all combination of BA with pinching. However, interaction of control × no pinching resulted early bud initiation.

4.1.2.2 Bud diameter

The data pertaining to the effect of BA, pinching and their combinations treatments on bud diameter. It is evident from the results showed in Table 4.7. The maximum bud diameter was reported with pinching (15.62 mm) followed by non-pinching (15.09 mm). Among the BA, BA 150 ppm (16.97 mm) had maximum bud diameter followed by BA 250 ppm, BA 50 ppm and was significant to all other treatments. However, minimum bud diameter was reported in BA 200 ppm (14.07 mm) was significant to all other treatments. Among interactions of BA with pinching, maximum bud diameter was found with interaction of BA 150 ppm × pinching (19.32 mm) followed by interactions of BA 250 ppm × pinching, BA 50 ppm × pinching and significant to all other interaction. Interaction of BA 200 ppm × pinching recorded minimum bud diameter.

Table 4.7: Effect of BA and pinching on days to bud initiation and bud diameter in calendula.

Treatment	Days to bud initiation (Days)	Bud diameter (mm)
No pinching	46.39	15.09
Pinching	60.02	15.62
C.D. at 5%	0.72	0.24
Control	50.00	14.72
BA 50ppm	54.41	15.83
BA 100ppm	54.22	14.46
BA 150 ppm	52.38	16.97
BA 200ppm	52.91	14.07
BA 250ppm	55.30	16.45
BA 300ppm	53.22	14.98
C.D. at 5%	1.36	0.46
Interaction (T×P)		
Control × No pinching	44.00	14.59
BA 50 ppm × No pinching	46.67	15.28
BA 100 ppm × No pinching	51.22	15.20
BA 150 ppm × No pinching	43.61	14.61
BA 200 ppm × No pinching	46.00	15.03
BA 250 ppm × No pinching	46.72	16.14
BA 300 ppm × No pinching	46.56	14.76
Control × Pinching	56.01	14.85
BA 50 ppm × Pinching	62.16	16.39
BA 100 ppm × Pinching	57.22	13.72
BA 150 ppm × Pinching	61.16	19.32
BA 200 ppm × Pinching	59.83	13.11
BA 250 ppm × Pinching	63.89	16.77
BA 300 ppm × Pinching	59.89	15.19
C.D. at 5%	1.92	0.66

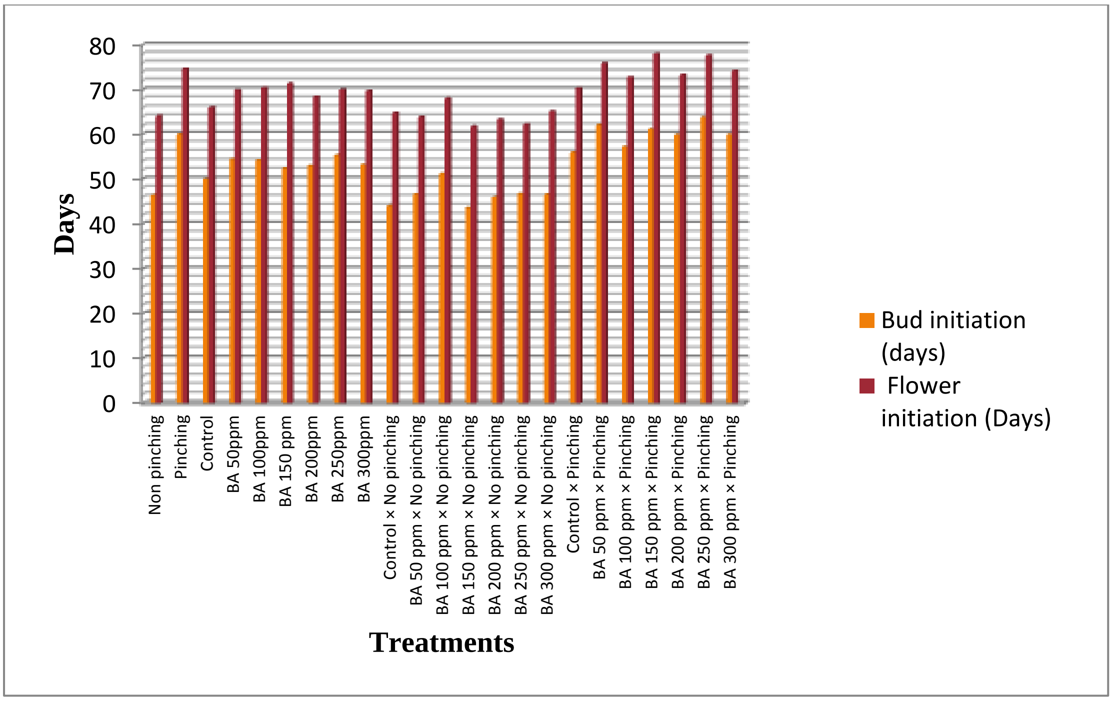

Fig. 4.9 **Effect of BA and pinching on days to bud initiation and flower initiation in calendula**

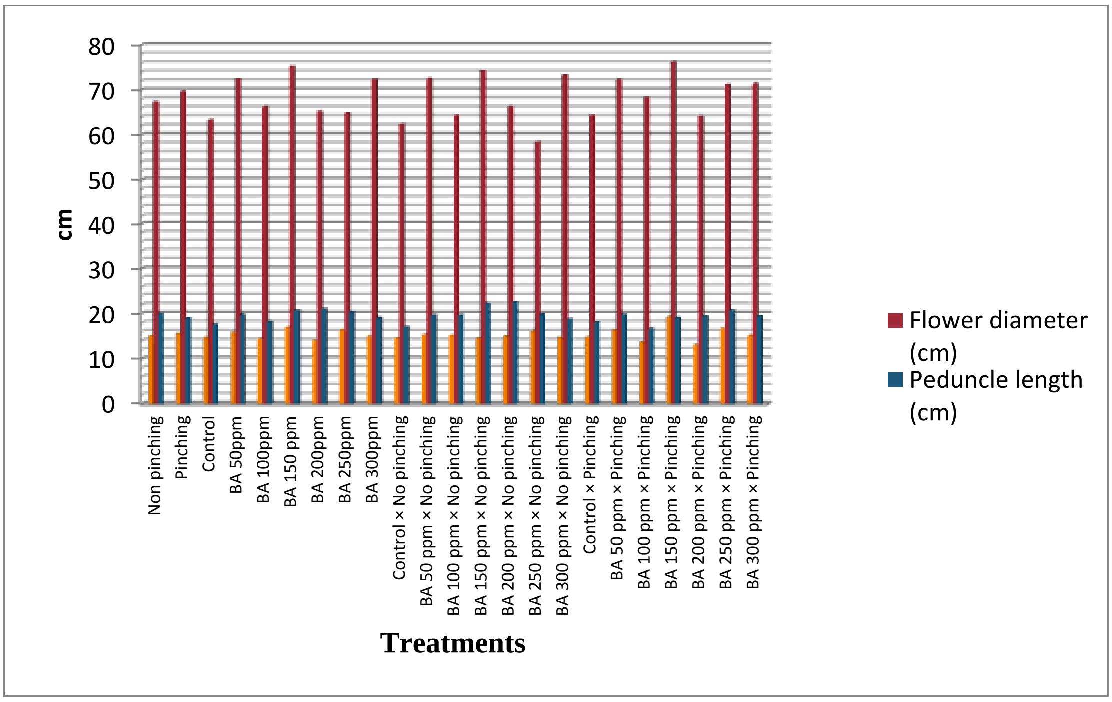

Fig. 4.10: **Effect of BA and pinching on flower diameter and peduncle length in calendula.**

4.1.2.3 Days to flower initiation

The data regarding effect of BA, pinching and their interactions on days to flower initiation is presented in Table 4.8 and Fig. 4.9. The days to flower initiation in calendula is significantly influenced due to BA, pinching and their interactions. Treatment pinching (74.63 days) resulted maximum days to flower initiation compared to no pinching (64.23 days). Treatment BA 150 ppm (71.44 days) recorded maximum days to flower initiation which was at par with treatments BA 100 ppm, BA 250 ppm, BA 50 ppm and significantly higher to all other treatments. While, minimum days to flower initiation was found with control. Maximum days to flower initiation was recorded with interaction of BA 150 ppm × pinching (78.05 days) which was significantly at par with interactions of BA 250 ppm × pinching and BA 50 ppm × pinching. While, interactions of BA 150 ppm × no pinching resulted minimum days to flower initiation.

4.1.2.4 Flower diameter

Table 4.8 and Fig. 4.10 reveals that different contractions of BA, pinching and their interactions had to significant effect on flower diameter. Maximum flower diameter was observed with pinching (69.70 mm) which was significant to no pinching (67.36 mm). Maximum flower diameter was found with BA 150 ppm (75. 21 mm) significant to all other treatments. While, minimum flower diameter was recorded with control. Among various interactions between pinching and BA, maximum flower diameter was reported with interactions of BA 150 ppm × pinching (76.20 mm) which was at par with interaction of BA 150 ppm × no pinching and significant to all other interactions. While, minimum flower diameter was found with interactions of BA 250 ppm × no pinching.

Table 4.8: Effect of BA and pinching on days to flower initiation and flower diameter in calendula.

Treatment	Flower initiation (Days)	Flower diameter (mm)
No pinching	64.23	67.36
Pinching	74.63	69.70
C.D. at 5%	0.86	0.79
Control	66.08	63.36
BA 50ppm	69.91	72.42
BA 100ppm	70.44	66.30
BA 150 ppm	71.44	75.21
BA 200ppm	68.41	65.24
BA 250ppm	70.03	64.83
BA 300ppm	69.72	72.37
C.D. at 5%	1.60	1.47
Interaction (T×P)		
Control × No pinching	64.83	62.37
BA 50 ppm × No pinching	63.94	72.53
BA 100 ppm × No pinching	68.05	64.27
BA 150 ppm × No pinching	61.89	74.21
BA 200 ppm × No pinching	63.44	66.35
BA 250 ppm × No pinching	62.33	58.43
BA 300 ppm × No pinching	65.17	73.36
Control × Pinching	70.28	64.34
BA 50 ppm × Pinching	75.89	72.30
BA 100 ppm × Pinching	72.83	68.33
BA 150 ppm × Pinching	78.05	76.20
BA 200 ppm × Pinching	73.37	64.13
BA 250 ppm × Pinching	77.72	71.23
BA 300 ppm × Pinching	74.27	71.38
C.D. at 5%	2.26	2.08

4.1.2.5 Peduncle length

The data pertaining to peduncle length as significantly influenced due to different concentration of BA, pinching and their interaction is presented in table 4.9 and depicted in Fig. 4.10. No pinching resulted maximum peduncle length (20.03 cm) which was significantly higher than pinching (19.08 cm). Maximum peduncle length was recorded with treatment BA 200 ppm (21.07 cm) which was at par with BA 150 ppm and significantly higher to all other treatments. While untreated plants resulted minimum peduncle length. Interaction of BA 200 ppm × no pinching (22.26 cm) resulted maximum peduncle length which was at par with interaction of BA 150 ppm × no pinching and significant to all other interactions. While, minimum peduncle length was found with interaction of control × no pinching.

4.1.2.6 Days to flower withering

The data regarding the effect of BA, pinching and their interactions on days to flower withering is presented in Table 4.9 and illustrated in Fig. 4.12. Days to flower withering is significantly influenced by various levels of BA, pinching and their interactions in calendula. Maximum days to flower withering was recorded with pinching (83.47 days) which was significant to no pinching. Maximum day to flower withering was recorded with treatment BA 50 ppm (80.69 days) and significant to all other treatments. While minimum days to flower withering was observed with control. Interaction of BA 50 ppm × pinching (87.28 days) showed maximum days to withering of flower which was at par with interactions of BA 250 ppm × pinching, BA 150 ppm × pinching and was significant to all other combinations. While, minimum days to flower withering was observed with interaction of BA 150 ppm × no pinching.

4.1.2.7 Number of flowers/plant

The effect of different levels of BA, pinching and their combinations on number of flower/plant were found significant that is represented in Table 4.9. Pinching resulted maximum number of flowers/plant (228.66) which was significantly higher than no pinching (211.52).

Table 4.9: Effect of BA and pinching on peduncle length, number of flower/plant and days to flower withering in calendula.

Treatment	Peduncle length (cm)	Number of flowers/plant	Days to flower withering (Days)
No pinching	20.03	211.52	72.46
Pinching	19.08	228.66	83.47
C.D. at 5%	0.33	4.07	0.80
Control	17.59	199.33	74.79
BA 50ppm	19.80	205.83	80.69
BA 100ppm	18.22	240.50	79.00
BA 150 ppm	20.69	210.83	77.67
BA 200ppm	21.07	240.67	77.11
BA 250ppm	20.35	215.83	78.79
BA 300ppm	19.17	227.67	77.72
C.D. at 5%	0.63	7.6	1.50
Interaction (T×P)			
Control × No pinching	17.05	185.33	70.41
BA 50 ppm × No pinching	19.73	193.33	74.11
BA 100 ppm × No pinching	19.77	239.00	76.05
BA 150 ppm × No pinching	22.26	202.00	70.17
BA 200 ppm × No pinching	22.60	235.33	71.61
BA 250 ppm × No pinching	19.93	222.00	71.68
BA 300 ppm × No pinching	18.87	203.67	73.17
Control × Pinching	18.13	213.33	79.16
BA 50 ppm × Pinching	19.87	218.33	87.28
BA 100 ppm × Pinching	16.66	242.00	81.94
BA 150 ppm × Pinching	19.12	219.67	85.16
BA 200 ppm × Pinching	19.53	246.00	82.61
BA 250 ppm × Pinching	20.77	209.67	85.89
BA 300 ppm × Pinching	19.48	251.67	82.27
C.D. at 5%	0.89	10.75	2.12

Maximum number of flowers/plant recorded with BA 200 ppm (240.67) which was at par with BA 100 ppm and significant to all other treatment. While, minimum number of flowers/plant was recorded with untreated plants. Maximum number of flowers/plants was observed with combination of BA 300 ppm × pinching (251.67) which was at par with interactions of BA 200 ppm × pinching, BA 100 ppm × pinching However, minimum number of flowers/plants was obtained with interaction of control × no pinching.

4.1.2.8 Fresh weight of flower

The data pertaining to fresh weight of flower as significantly influenced due to different concentration of BA, pinching and their interactions is given in Table 4.10 and illustrated in Fig. 4.11. The pinching resulted maximum fresh weight of flower (9.54 g) which was significant to no pinching (7.62 g). Maximum fresh weight of flower (10.29 g) was observed with treatment BA 200 ppm which was at par with treatment BA 50 ppm and significant to all other treatments. Whereas, minimum fresh weight was observed with control. The interaction of BA 150 ppm × pinching (12.01 g) registered maximum fresh weight of flower which was at par with interactions of BA 200 ppm × pinching, BA 50 ppm × pinching and significantly higher than other treatment combinations. While, minimum fresh weight of flower recorded in combination of control × no pinching.

4.1.2.9 Dry weight of flower

The data on dry weight of flower was significantly influenced by various concentrations of BA and pinching as furnished in Table 4.10 and illustrated in Fig. 4.11. However, interactions of pinching with BA failed to exert any significant variation. Maximum dry weight of flower was noted with pinched plant (1.22 g) which was significant to no pinching treatment (1.01 g). It was ascertained from data that maximum dry weight of flower was noticed with treatment BA 200 ppm (1.31 g) which was at par with treatment BA 150 ppm, 50 ppm, BA 250 ppm and significant to other all treatment. However, minimum dry weight of flower was noted with control.

Table 4.10: Effect of BA and pinching on fresh and dry weight of flower in calendula

Treatment	Fresh weight of flower (g)	Dry weight of flower (g)
No pinching	7.62	1.01
Pinching	9.54	1.22
C.D. at 5%	0.36	0.15
Control	6.47	0.86
BA 50ppm	10.06	1.28
BA 100ppm	7.14	0.92
BA 150 ppm	9.54	1.24
BA 200ppm	10.29	1.31
BA 250ppm	8.94	1.19
BA 300ppm	7.63	0.99
C.D. at 5%	0.67	0.28
Interaction (T×P)		
Control × No pinching	6.11	0.90
BA 50 ppm × No pinching	8.73	1.10
BA 100 ppm × No pinching	7.86	1.03
BA 150 ppm × No pinching	7.06	0.92
BA 200 ppm × No pinching	8.92	1.21
BA 250 ppm × No pinching	7.52	1.02
BA 300 ppm × No pinching	7.13	0.87
Control × Pinching	6.82	0.82
BA 50 ppm × Pinching	11.39	1.46
BA 100 ppm × Pinching	6.41	0.81
BA 150 ppm × Pinching	12.01	1.56
BA 200 ppm × Pinching	11.65	1.41
BA 250 ppm × Pinching	10.36	1.35
BA 300 ppm × Pinching	8.13	1.11
C.D. at 5%	0.95	NS

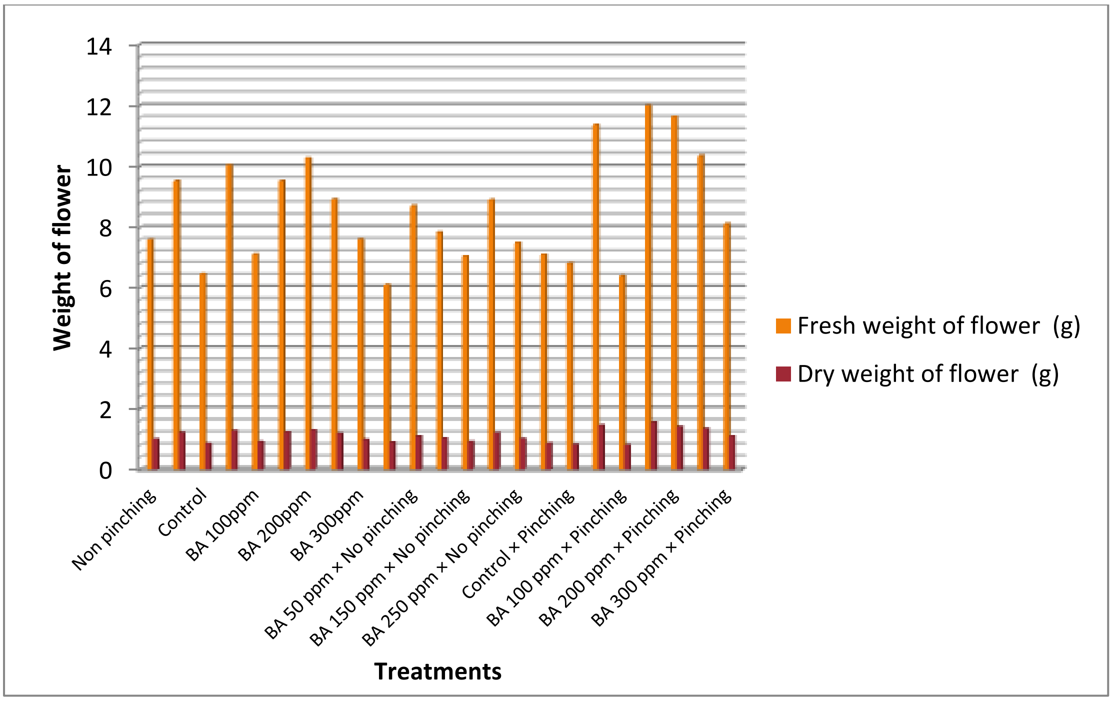

Fig. 4.11: Effect of BA and pinching on fresh and dry weight of flower in calendula

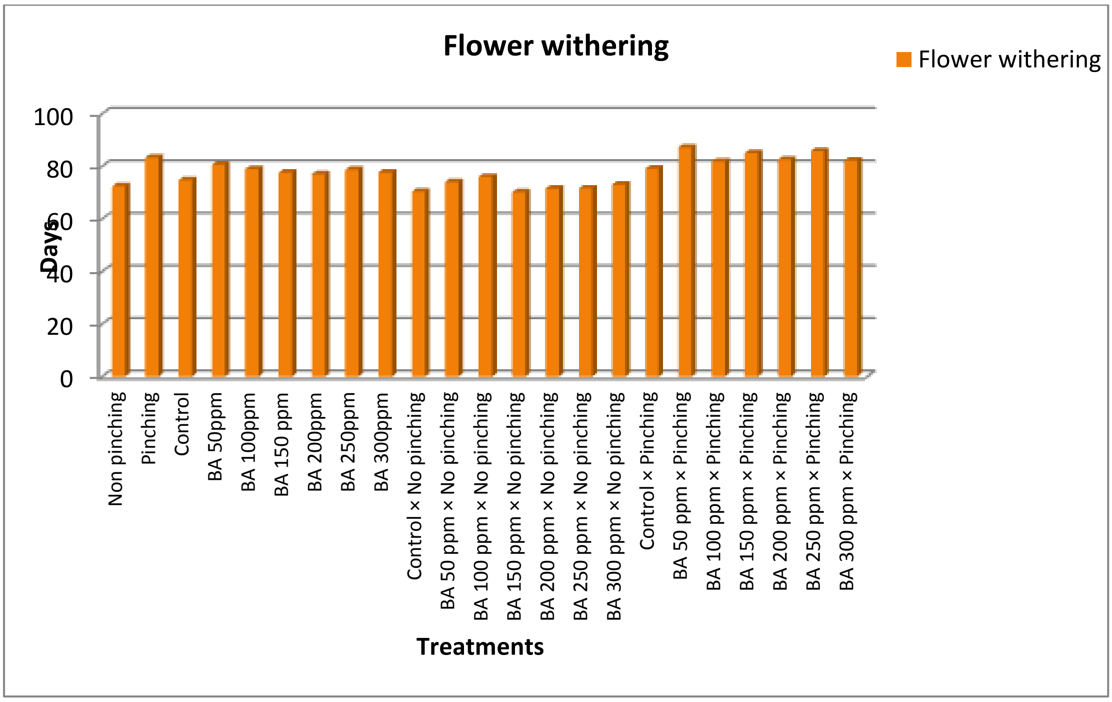

Fig. 4.12: Effect of BA and pinching on flower withering in calendula

4.1.3 Effect of BA and pinching on seed characters

4.1.3.1 Days to seed maturity

The data on days to seed maturity was influenced by BA, pinching with their interactions is presented in Table 4.11 and Fig. 4.13. Pinching treatment resulted maximum days to seed maturity (104.82 days) which was significantly higher than no pinching (93.79 days). As regard the effect of BA application, maximum days to seed maturity was recorded with treatment BA 200 ppm (101.02 days) which was at par with treatment BA 250 ppm and significant to all other treatment. Minimum days to seed maturity was observed with control. Combination effect of BA × pinching revealed that maximum days to seed maturity was noticed with interaction of BA 250 ppm × pinching (108.22 days) which at par with interactions of BA 200 ppm × pinching, BA 150 ppm × pinching and significant to all other combinations. However, minimum days to seed maturity was reported with interaction of BA 50 ppm × no pinching.

4.1.3.2 Seed yield/plant

The data pertaining to influence of various levels of BA, pinching and their interactions on seed yield/plant was significant (Table 4.11 and illustrated in Fig. 4.14). Maximum seed yield/plant recorded with pinching (41.00 g) which was statistically higher than no pinching (34.91 g). Various levels of BA have a significant effect on seed yield/plant. Maximum seed yield/plant was noted with treatment BA 150 ppm (43.23 g) which was at par with treatment BA 200 ppm and significant to all other treatments. While, minimum seed yield/plant was recorded with control. Interactions of BA 200 ppm × pinching (49.89 g) recorded maximum seed yield/plant followed by interactions of BA 150 ppm × no pinching, BA 250 ppm × pinching and significant to all other combinations. However, minimum seed yield/plant was noted with interaction of control × no pinching.

Table 4.11: Effect of BA and pinching on days to seed maturity and seed yield/plant in calendula

Treatment	**Days to seed maturity (Days)**	**Seed yield/plant (g)**
No pinching	93.79	34.91
Pinching	104.82	41.00
C.D. at 5%	0.70	0.97
Control	95.11	31.27
BA 50ppm	98.83	39.91
BA 100ppm	100.60	33.94
BA 150 ppm	100.16	43.23
BA 200ppm	101.02	42.66
BA 250ppm	100.80	40.88
BA 300ppm	98.58	33.81
C.D. at 5%	1.30	1.81
Interaction (T×P)		
Control × No pinching	92.61	19.98
BA 50 ppm × No pinching	92.61	39.42
BA 100 ppm × No pinching	96.61	32.50
BA 150 ppm × No pinching	93.33	46.38
BA 200 ppm × No pinching	95.00	35.43
BA 250 ppm × No pinching	93.39	38.10
BA 300 ppm × No pinching	92.94	32.53
Control × Pinching	97.61	42.56
BA 50 ppm × Pinching	105.05	40.39
BA 100 ppm × Pinching	104.60	35.38
BA 150 ppm × Pinching	107.00	40.07
BA 200 ppm × Pinching	107.05	49.89
BA 250 ppm × Pinching	108.22	43.66
BA 300 ppm × Pinching	104.22	35.08
C.D. at 5%	1.84	2.56

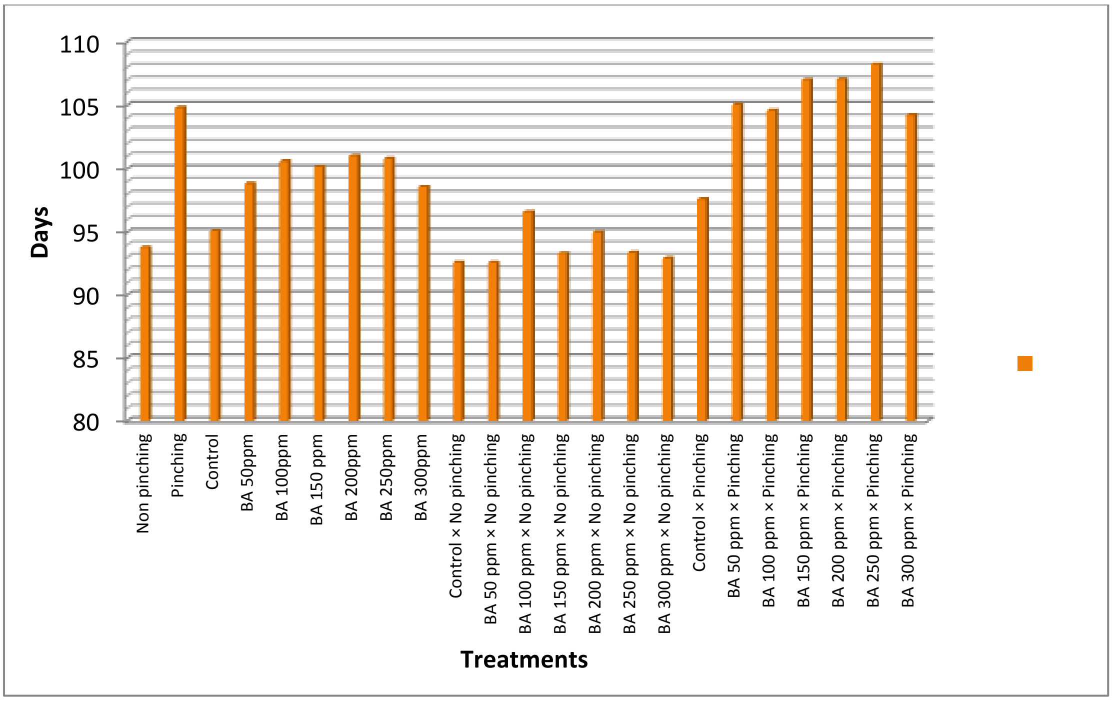

Fig. 4.13: Effect of BA and pinching on days to seed maturity in calendula.

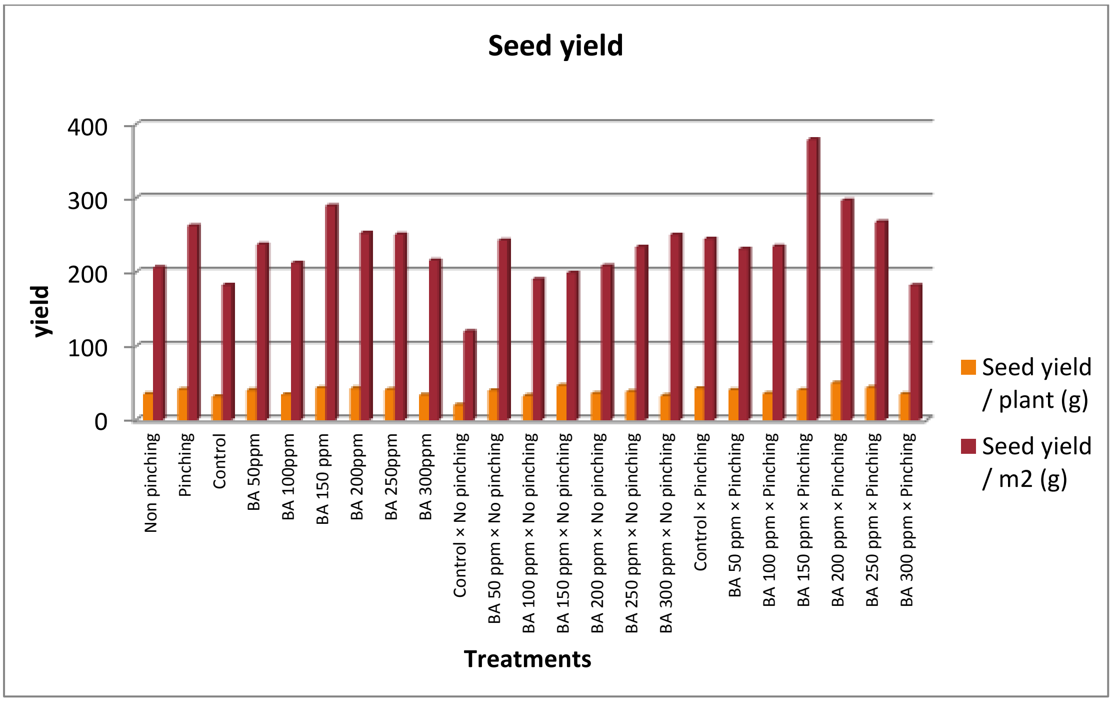

Fig. 4.14: Effect of BA and pinching on seed yield per plant and seed yield per meter^2 in calendula

4.1.3.3 Seed yield/meter^2

The data regarding seed yield/m^2 depicted in Table 4.12 and illustrated in Fig. 4.14 indicated that various level of BA, pinching and their interactions significantly influenced on seed yield/m^2 in calendula. Maximum seed yield/m^2 (262.39 g) was recorded with pinched plants compared to non-pinched plants (206.33 g). Treatment BA 150 ppm (289.25 g) showed maximum seed yield/meter^2 followed by treatments BA 200 ppm, BA 250 ppm which was statistically significant to all other treatments. However, minimum seed yield/m^2 was observed with control. The interaction of BA 150 ppm × pinching (379.50 g) registered maximum seed yield/m^2 followed by interaction of BA 200 ppm × pinching which was significant to all other interaction. Minimum seed yield/m^2 was recorded with interaction of control × no pinching.

4.1.3.4 Test weight

It is depicted in Table 4.12 and illustrated in Fig. 4.15 that test weight was significantly influenced by different concentrations of BA, pinching and their interactions in calendula. Pinched plants showed significantly maximum test weight (10.05 g) compared to non-pinched plants (9.14 g). Among BA treatment, BA 150 ppm observed maximum test weight (10.55 g) which was at par with treatments BA 250 ppm, BA 300 ppm, BA 200 ppm, BA 50 ppm and was significant to all other treatments. Whereas, minimum test weight was recorded with untreated plants. The interactions of BA 250 ppm × pinching (11.22 g) registered maximum test weight followed by interactions of BA 200 ppm × pinching, BA 150 ppm × pinching, BA 150 ppm × no pinching was significantly to all other interaction. Whereas, interaction of BA 100 ppm × no pinching (8.24 g) recorded minimum test weight.

Table 4.12: Effect of BA and pinching on seed yield/meter^2 and test weight in calendula

Treatment	**Seed yield/m^2 (g)**	**Test weight (g)**
No pinching	206.33	9.14
Pinching	262.39	10.05
C.D. at 5%	4.38	0.63
Control	182.32	8.81
BA 50ppm	237.08	9.61
BA 100ppm	212.46	9.00
BA 150 ppm	289.25	10.55
BA 200ppm	252.51	9.65
BA 250ppm	250.89	9.90
BA 300ppm	216.01	9.67
C.D. at 5%	8.20	1.18
Interaction (T×P)		
Control × No pinching	119.67	8.41
BA 50 ppm × No pinching	242.90	9.40
BA 100 ppm × No pinching	190.16	8.24
BA 150 ppm × No pinching	199.00	10.51
BA 200 ppm × No pinching	208.22	8.63
BA 250 ppm × No pinching	234.11	8.59
BA 300 ppm × No pinching	250.27	10.23
Control × Pinching	244.98	9.20
BA 50 ppm × Pinching	231.27	9.82
BA 100 ppm × Pinching	234.76	9.76
BA 150 ppm × Pinching	379.50	10.59
BA 200 ppm × Pinching	296.80	10.68
BA 250 ppm × Pinching	267.67	11.22
BA 300 ppm × Pinching	181.75	9.10
C.D. at 5%	11.59	1.67

4.1.3.5 Number of seeds/flower

The data pertaining to number of seeds/flower is presented on Table 4.13 and Fig. 4.16 resulted different concentration of BA along with pinching and their interaction had significant effect on number of seeds/flower. Maximum number of seeds/flower (32.72) was recorded with treatment pinching which was statistically higher than non pinching (31.15). Maximum number of seeds/flower was found with treatment BA 150 ppm (33.58) which was at par with treatment BA 100 ppm, BA 300 ppm and which was significantly to all other treatments. Interaction of BA × pinching resulted in statistically significant effect on number of seeds/flower. Maximum number of seeds/flower was reported with interaction of BA 100 ppm × no pinching (36.42) which was at par with interaction of BA 50 ppm × pinching and which was significant all other combinations. Whereas, minimum number of seeds/flower was recorded with interaction of control × no pinching.

Tables 4.13: Effect of BA and pinching on number of seeds/flower in calendula

Treatment	**Number of seed/flowers**
No pinching	31.15
Pinching	32.72
C.D. at 5%	0.63
Control	27.17
BA 50ppm	31.65
BA 100ppm	33.16
BA 150 ppm	33.58
BA 200ppm	32.08
BA 250ppm	32.88
BA 300ppm	33.02
C.D. at 5%	1.18
Interaction (T×P)	
Control × No pinching	25.92
BA 50 ppm × No pinching	28.12
BA 100 ppm × No pinching	36.42
BA 150 ppm × No pinching	33.65
BA 200 ppm × No pinching	29.85
BA 250 ppm × No pinching	31.72
BA 300 ppm × No pinching	32.33
Control × Pinching	28.41
BA 50 ppm × Pinching	35.17
BA 100 ppm × Pinching	29.90
BA 150 ppm × Pinching	33.51
BA 200 ppm × Pinching	34.31
BA 250 ppm × Pinching	34.03
BA 300 ppm × Pinching	33.72
C.D. at 5%	1.67

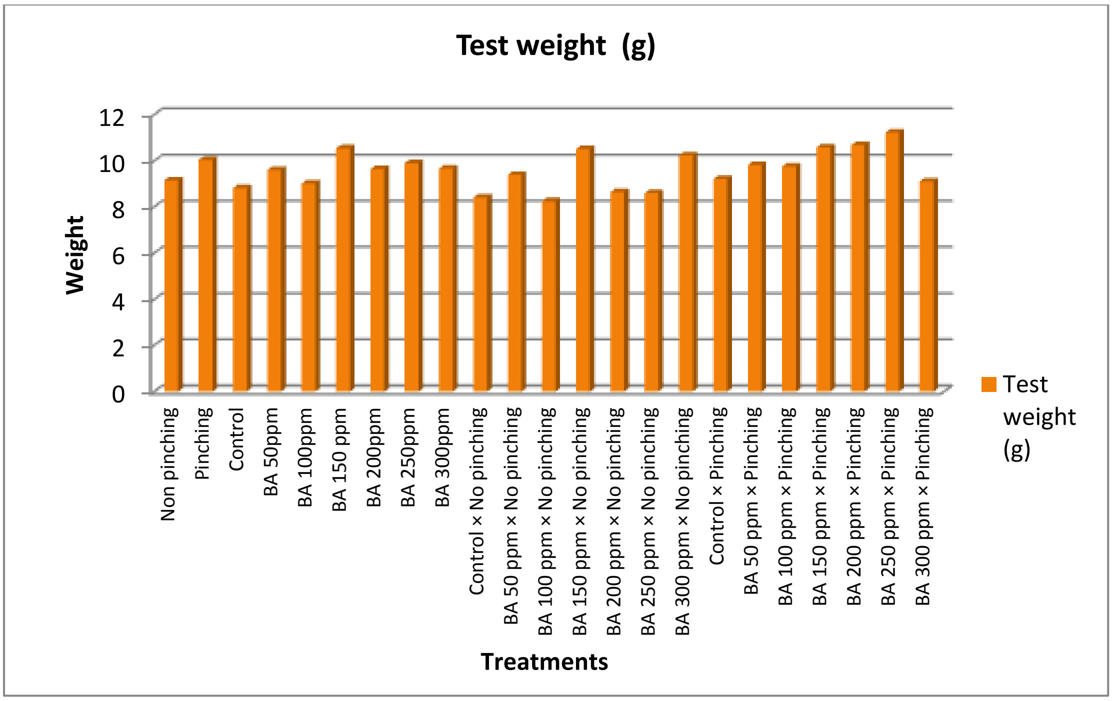

Fig. 4.15: Effect of BA and pinching on test weight in calendula.

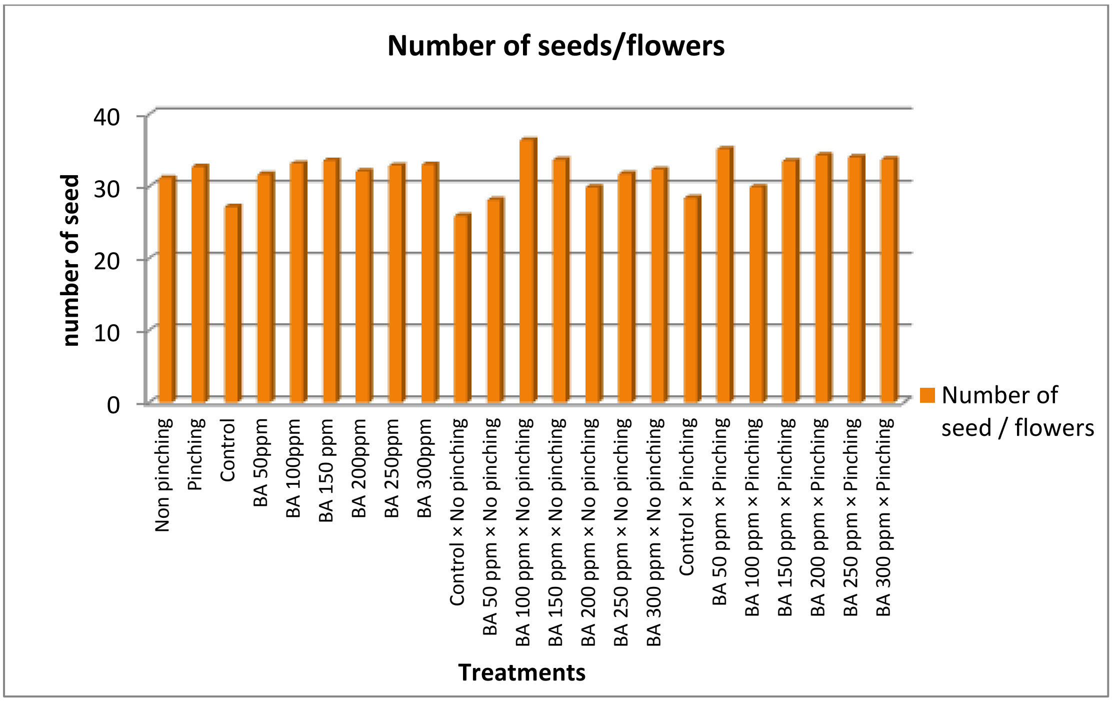

Fig. 4.16: Effect of BA and pinching on number of seeds/flower in calendula.

4.2 Experiment no. 2: Effect of BA and pinching on growth, flowering and seed yield parameters in phlox

4.2.1 Effect of BA and pinching on vegetative parameters

4.2.1.1 Plant height at 60 DAT

A perusal of data embodied in Table 4.14 and illustrated in Fig. 4.17 exhibited significant effect due to various levels BA, pinching and their interactions on plant height at 60 DAT in phlox. Maximum plant height was observed with treatment no pinching (7.68 cm) which was significant to treatment pinching. The maximum plant height (8.47 cm) was observed with treatment BA 200 ppm which was at par with control, BA 200 ppm and significant to all other treatment. However, minimum plant height was observed with treatment BA 300 ppm. Interaction of BA and pinching had significant effect on plant height. Maximum plant height (8.78 cm) was noted with interaction of BA 200 ppm × no pinching which was at par with interactions of control × no pinching, BA 250 ppm × no pinching, BA 250 × pinching and which was significant to all other interactions. While, minimum plant height was reported with interaction of BA 300 ppm × pinching.

4.2.1.2 Plant height at 90 DAT

It is depicted in Table 4.14 and Fig 4.17 that different concentrations of BA, pinching and their combinations had significant effect on plant height at 90 days in phlox. Maximum plant height was reported with treatment no pinching (38.86 cm) which was significant higher than pinching. Among the BA, Maximum plant height (38.23 cm) was noticed with treatment BA 200 ppm followed by control, BA 250 ppm and significant to all other treatments. While, minimum plant height was found with treatment BA 300 ppm. maximum plant height was reported with combination of BA 200 ppm × no pinching (46.78 cm) followed by interactions of control × no pinching, BA 150 ppm × no pinching, BA 100 ppm × no pinching and significant to all other combinations. Whereas, minimum plant height was recorded with interaction of BA 200 ppm × pinching.

Table 4.14: Effect of BA and pinching on plant height at 60 and 90 DAT in phlox

Treatment	**Plant height at 60 DAT (cm)**	**Plant height at 90 DAT (cm)**
No pinching	7.68	38.86
Pinching	6.68	34.04
C.D. at 5%	0.47	0.43
Control	8.09	36.83
BA 50 ppm	6.78	36.04
BA 100 ppm	7.28	36.00
BA 150 ppm	6.86	36.42
BA 200 ppm	8.47	38.23
BA 250 ppm	7.73	35.50
BA 300 ppm	5.05	36.16
C.D. at 5%	0.89	0.81
Interaction (T×P)		
Control × No pinching	8.77	41.66
BA 50 ppm × No pinching	7.17	33.60
BA 100 ppm × No pinching	8.03	39.00
BA 150 ppm × No pinching	7.33	39.67
BA 200 ppm × No pinching	8.78	46.78
BA 250 ppm × No pinching	7.57	35.67
BA 300 ppm × No pinching	6.20	35.65
Control × Pinching	8.16	32.00
BA 50 ppm × Pinching	6.38	38.47
BA 100 ppm × Pinching	6.53	33.00
BA 150 ppm × Pinching	6.38	33.17
BA 200 ppm × Pinching	7.40	29.67
BA 250 ppm × Pinching	7.90	35.33
BA 300 ppm × Pinching	3.90	36.67
C.D. at 5%	1.25	1.15

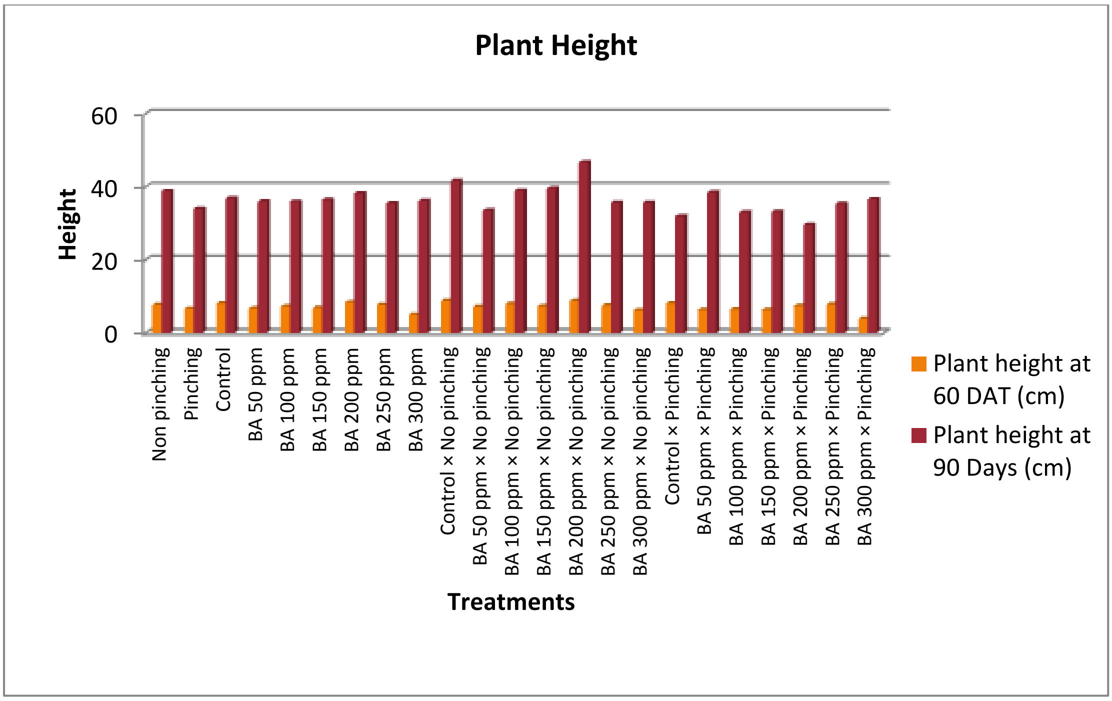

Fig. 4.17 Effect of BA and pinching on plant height at 60 and 90 DAT in phlox.

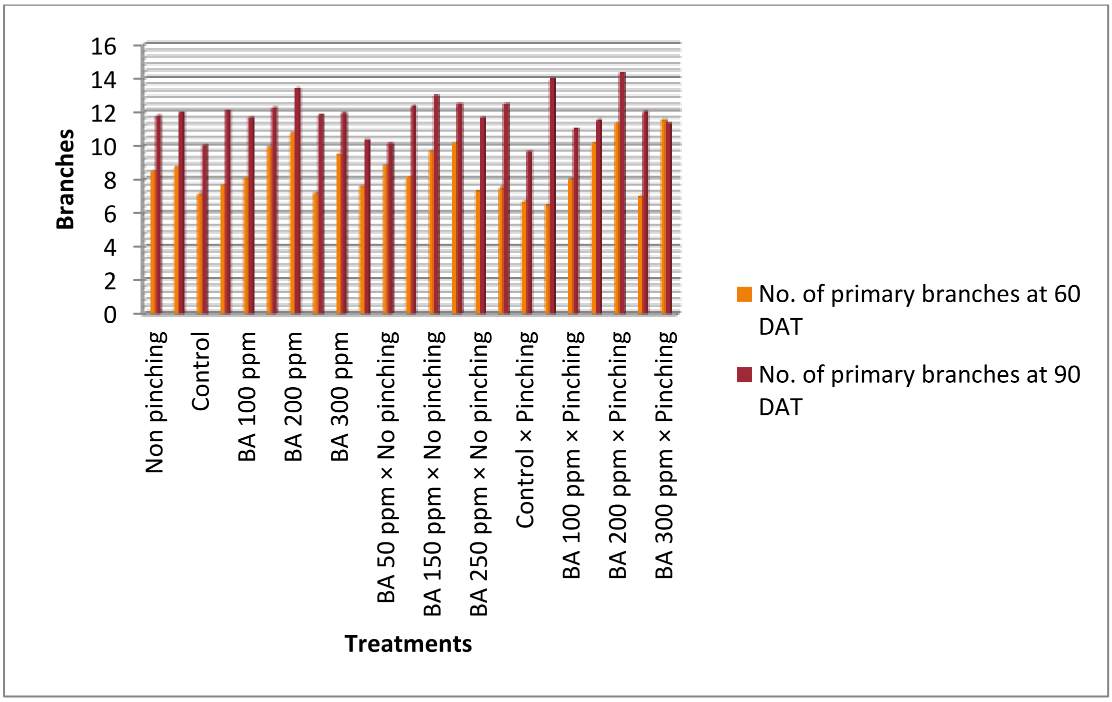

Fig. 4.18 Effect of BA and pinching on number of primary branches/plant at 60 and 90 DAT in phlox

4.2.1.3 Number of primary branches/plant at 60 DAT

The data related to number of primary branches/plant of phlox recorded at 60 DAT is presented in Table 4.15 and depicted in Fig.4.18 which reveals that BA, pinching and their interactions had significant influence on number of primary branches/plant. Pinched plants recorded maximum number of primary branches/plant (8.74) compared to non pinched plant. Treatment BA 200 ppm exhibited maximum number of primary branches/plant (10.75) followed by BA 150 ppm, BA 300 ppm and significant to all other treatments. However, minimum number of primary branches/plant was recorded with control. The interaction effect of BA × pinching revealed that maximum number of primary branches/plant was noted with interaction of BA 300 ppm × pinching (11.50) which was at par with interaction of BA 200 ppm × pinching and significant to all other interactions. Whereas, minimum number of primary branches/plant was reported with interaction of BA 50 ppm × pinching.

4.2.1.4 Number of primary branches per plant at 90 DAT

A perusal of data presented in Table 4.15 indicated significant effects of BA, pinching and their interactions on number of primary branches/plant at 90 DAT in phlox. Maximum number of primary branches (11.97) was recorded with treatment pinching and minimum number of primary branches of was recorded with treatment no pinching. Among different doses of BA, Maximum number of primary branches was noticed with BA 200 ppm (13.42) followed by BA 150 ppm, BA 50 ppm and significant to all other treatment. Whereas, minimum number of primary branches was noticed with control. Among the interactions of BA and pinching, maximum number of primary branches/plant was observed with interaction of BA 200 ppm × pinching (14.33) which was at par with interaction of BA 50 ppm × pinching and significant to all other interactions However, minimum number of primary branches/plant was noted with interaction of control × pinching.

Table 4.15: Effect of BA and pinching on number of primary branches/plant at 60 and 90 DAT in phlox

Treatment	No. of primary branches at 60 DAT	No. of primary branches at 90 DAT
No pinching	8.47	11.78
Pinching	8.74	11.97
C.D. at 5%	0.27	0.14
Control	7.13	10.00
BA 50 ppm	7.67	12.08
BA 100 ppm	8.08	11.67
BA 150 ppm	9.92	12.25
BA 200 ppm	10.75	13.42
BA 250 ppm	7.17	11.83
BA 300 ppm	9.50	11.92
C.D. at 5%	0.50	0.26
Interaction (T×P)		
Control × No pinching	7.60	10.33
BA 50 ppm × No pinching	8.83	10.16
BA 100 ppm × No pinching	8.17	12.33
BA 150 ppm × No pinching	9.67	13.00
BA 200 ppm × No pinching	10.16	12.50
BA 250 ppm × No pinching	7.33	11.66
BA 300 ppm × No pinching	7.50	12.50
Control × Pinching	6.67	9.66
BA 50 ppm × Pinching	6.50	14.00
BA 100 ppm × Pinching	8.00	11.00
BA 150 ppm × Pinching	10.17	11.50
BA 200 ppm × Pinching	11.33	14.33
BA 250 ppm × Pinching	7.00	12.00
BA 300 ppm × Pinching	11.50	11.33
C.D. at 5%	0.71	0.36

4.2.1.5 Number of secondary branches/plant

A review of the data in Table 4.16 and graphically illustrated in Fig. 4.19 revealed that BA, pinching and their interactions had significant effect on the number of secondary branches/plant. Pinching resulted maximum number of secondary branches (37.36) which was statistically significant to no pinching. Treatment BA 200 ppm (41.25) registered maximum secondary branches/plant followed by treatments BA 300 ppm, BA 150 ppm and significant to all other treatments. Whereas, treatment BA 100 ppm resulted minimum number of secondary branches/plant. Interaction of BA 200 ppm with pinching (43.50) exerted maximum number of secondary branches/plant which was at par with interactions of BA 300 ppm × pinching, BA 150 ppm × pinching and significant to all other treatments. While, minimum number of secondary branches/plant was found with interaction of BA 50 ppm × no pinching.

4.2.1.6 Plant spread at 60 DAT

The result revealed that various concentrations of BA and pinching treatment exhibited significant variation on plant spread at 60 DAT in phlox (Table 4.16 and Fig. 4.20). Whereas, interaction of BA with pinching failed to exert any significant effect on plant spread. Pinching showed maximum plant spread (20.32 cm) which was higher than no pinching. The maximum plant spread was measured with treatment BA 250 ppm (21.07 cm) which was at par with treatments BA 150 ppm, BA 200 ppm and significant to all other treatments. Whereas, minimum plant spread was measured with control. The combined effects of BA and pinching were found to be non significant for plant spread at 60 DAT

4.2.1.7 Plant spread at 90 DAT

The data on plant spread at 90 DAT was presented in Table 4.16 and Fig. 4.20 revealed that BA, pinching and their interactions had significant effect on plant spread at 90 DAT in phlox. Pinched plants had maximum plant spread (49.89 cm) which was significantly higher than the non pinched plants. Maximum plant spread was observed with treatment BA 200 ppm (53.75 cm) followed by treatments BA 100ppm, BA 300 ppm and significantly all other treatments.

Table 4.16: Effect of BA and pinching on number of secondary branches/plant and plant spread at 60 & 90 DAT in phlox

Treatment	**No. of secondary branches / plant**	**Plant spread at 60 DAT (cm)**	**Plant spread at 90 DAT (cm)**
No pinching	33.24	19.16	48.25
Pinching	37.36	20.32	49.89
C.D. at 5%	0.56	0.98	0.43
Control	32.50	17.24	46.33
BA 50 ppm	32.33	17.76	46.50
BA 100 ppm	29.08	19.54	50.75
BA 150 ppm	38.33	21.01	47.83
BA 200 ppm	41.25	20.58	53.75
BA 250 ppm	35.00	21.07	49.13
BA 300 ppm	38.60	20.98	49.21
C.D. at 5%	1.05	1.84	0.80
Interaction (T×P)			
Control × No pinching	33.50	16.77	45.17
BA 50 ppm × No pinching	28.00	18.68	45.17
BA 100 ppm × No pinching	29.83	17.84	47.92
BA 150 ppm × No pinching	34.17	19.84	50.42
BA 200 ppm × No pinching	39.00	20.32	53.25
BA 250 ppm × No pinching	34.50	19.99	50.08
BA 300 ppm × No pinching	33.70	20.67	45.75
Control × Pinching	31.50	17.72	47.50
BA 50 ppm × Pinching	36.67	16.85	47.83
BA 100 ppm × Pinching	28.33	21.23	53.58
BA 150 ppm × Pinching	42.50	22.17	45.25
BA 200 ppm × Pinching	43.51	20.84	54.25
BA 250 ppm × Pinching	35.50	22.16	48.17
BA 300 ppm × Pinching	43.50	21.29	52.67
C.D. at 5%	1.49	NS	1.14

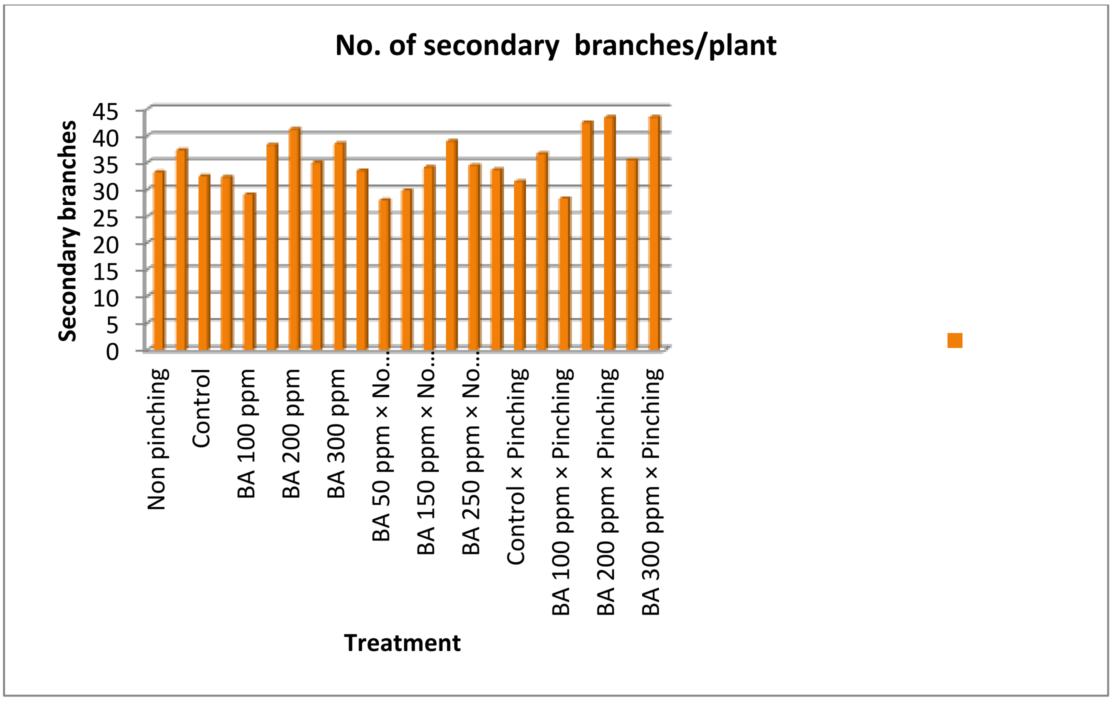

Fig. 4.19 Effect of BA and pinching on number of secondary branches/plant in phlox

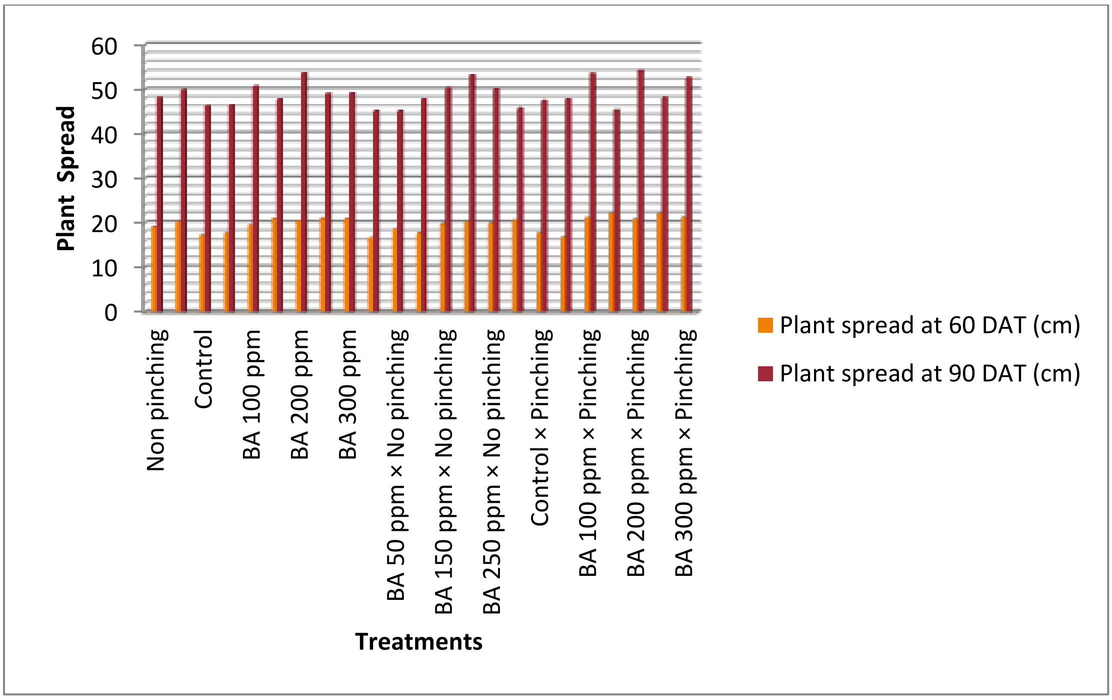

Fig. 4.20 Effect of BA and pinching on plant spread at 60 & 90 DAT in phlox

Whereas, minimum plant spread was recorded with control. Maximum plant spread (54.25 cm) was noted with interaction of BA 200 ppm × pinching which was at par with interactions of BA 100 ppm × pinching, BA 200 ppm × no pinching and significant to all other combinations. However, minimum plant spread was measured with control × no pinching (45.17 cm).

4.2.1.8 Stem diameter

Result showed that BA and pinching as well as interaction had a significant effect on stem diameter (Table 4.17 and Fig 4.21). Pinching showed maximum stem diameter (5.88 mm) which was significant to no pinching. BA 200 ppm (6.33 mm) registered maximum stem diameter followed by BA 300 ppm, BA 250 ppm and significant to all other treatments. While, minimum stem diameter (5.18 mm) was reported with control. Among the interaction of BA 200 ppm × pinching (6.72 mm) found maximum stem diameter which was at par with interactions of BA 250 ppm × pinching and significant to all other interactions. Whereas, minimum stem diameter was reported with interaction of BA 50 ppm × no pinching.

4.2.1.9 Fresh weight of leaves

A perusal of data presented in Table 4.17 and illustrated in Fig 4.21 indicated the significant effect of BA, pinching and their interactions on fresh weight of leaves in phlox. Fresh weight of leaves was reported with pinched plants (1.29 g) compared to no pinched plants. Maximum fresh weight of leaves was recorded with treatment BA 200 ppm (1.64 g) followed by BA 300 ppm and significant to all other treatments. While, minimum fresh weight of leaves was noticed with control. The interaction of foliar application of BA and pinching resulted in a statistically significant effect on fresh weight of leaves. Maximum fresh weight of leaves was noted with interaction of BA 200 ppm × pinching (1.94 g) followed by interactions of BA 100 ppm × no pinching, BA 300 ppm × no pinching, BA 250 ppm × no pinching and significant to all other combinations. Whereas, minimum fresh weight of leaves was found with interaction of control × no pinching.

Table 4.17: Effect of BA and pinching on stem diameter and fresh & dry weight of leaves in phlox.

Treatment	Stem diameter (mm)	Fresh weight of leaves (g)	Dry weight of leaves (g)
No pinching	5.33	1.27	0.22
Pinching	5.88	1.29	0.25
C.D. at 5%	0.19	0.02	0.003
Control	5.18	0.90	0.20
BA 50 ppm	5.20	1.10	0.23
BA 100 ppm	5.44	1.29	0.23
BA 150 ppm	5.44	1.27	0.25
BA 200 ppm	6.33	1.64	0.27
BA 250 ppm	5.82	1.32	0.24
BA 300 ppm	5.84	1.43	0.22
C.D. at 5%	0.35	0.03	0.006
Interaction (T×P)			
Control × No pinching	5.36	0.85	0.19
BA 50 ppm × No pinching	4.80	1.02	0.27
BA 100 ppm × No pinching	5.41	1.55	0.18
BA 150 ppm × No pinching	5.05	1.19	0.24
BA 200 ppm × No pinching	5.93	1.36	0.22
BA 250 ppm × No pinching	5.20	1.41	0.22
BA 300 ppm × No pinching	5.58	1.49	0.21
Control × Pinching	5.00	0.96	0.22
BA 50 ppm × Pinching	5.60	1.18	0.20
BA 100 ppm × Pinching	5.47	1.03	0.29
BA 150 ppm × Pinching	5.83	1.34	0.25
BA 200 ppm × Pinching	6.72	1.91	0.31
BA 250 ppm × Pinching	6.43	1.23	0.26
BA 300 ppm × Pinching	6.10	1.37	0.24
C.D. at 5%	0.49	0.05	0.008

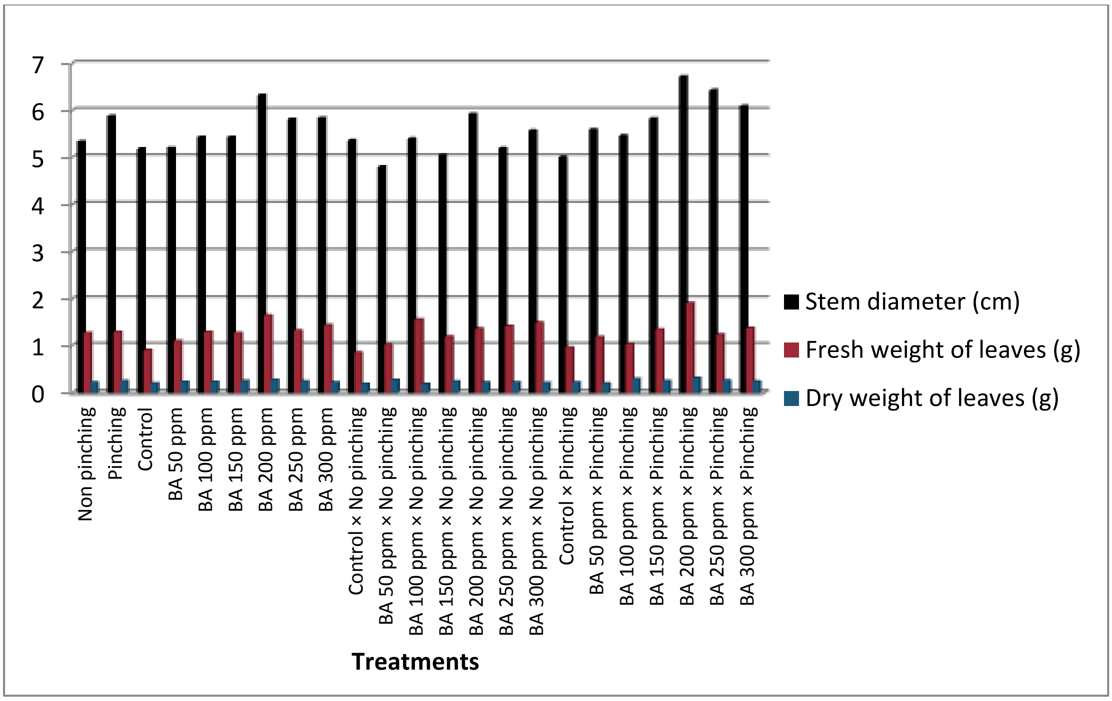

Fig. 4.21 **Effect of BA and pinching on stem diameter, fresh and dry weight of leaves in phlox**

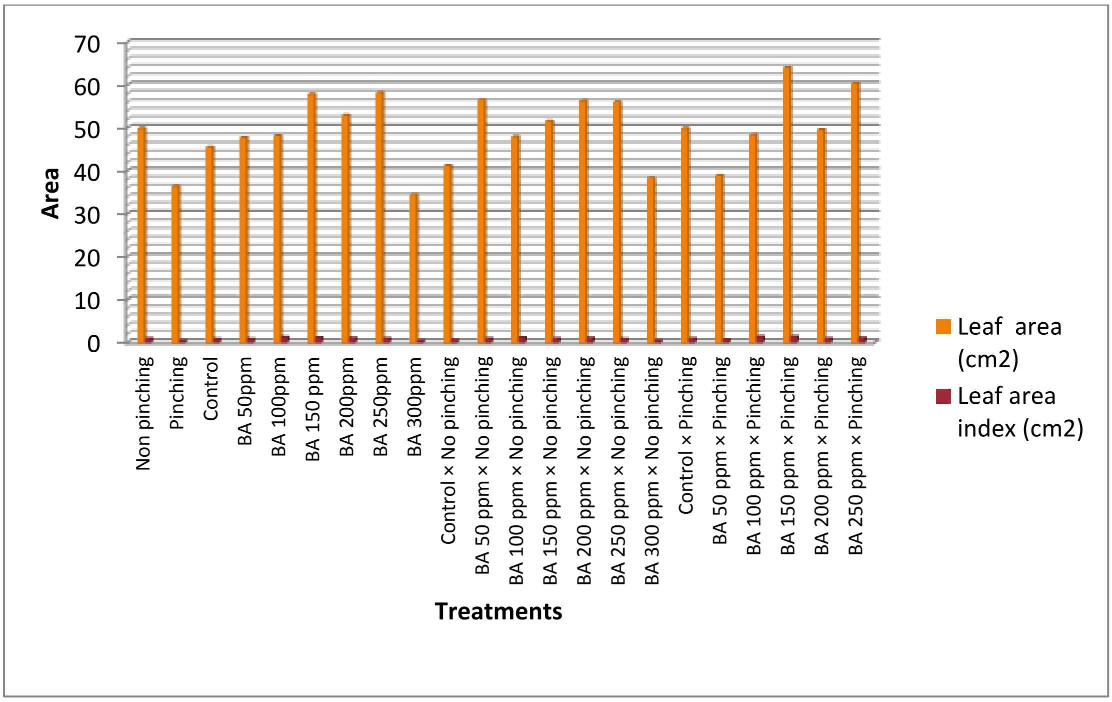

Fig. 4.22 Effect of BA and pinching on leaf area and leaf area index in phlox

4.2.1.10 Dry weight of leaves

The data regarding dry weight of leaves is presented in Table 4.17 and graphically outlined in Fig 4.21 indicated that effects of BA, pinching and their interactions resulted significant on dry leaf weight in phlox. Treatment pinching resulted maximum dry weight of leaves (0.25 g) which was significant to no pinching. Treatment BA 200 ppm (0.27 g) recorded maximum dry weight of leaves which was at par with treatments BA 150 ppm, BA 250 ppm and significant to all other treatments. However, minimum dry weight of leaves was noted with control. Maximum dry weight of leaves was noted with interaction of BA 200 ppm × pinching (0.31 g) followed by interactions of BA 100 ppm × pinching, BA 50 ppm × no pinching, BA 250 ppm × pinching and significant to all other interactions. Whereas, minimum dry weight of leaf was found with interaction of BA 100 ppm × no pinching.

4.2.1.11 Leaf area

The leaf area as influenced by various concentrations of BA, pinching and their interaction was significant (Table 4.18 and Fig. 4.22). Treatment pinching observed higher leaf area (49.91 cm^2) than no pinching. Treatment BA 300 ppm (58.21 cm^2) recorded maximum leaf area which was significantly at par with treatments BA 200 ppm and BA 250 ppm and significant to all other treatments. Whereas, minimum leaf area was found with control. The interaction of BA and pinching had a significantt influence on leaf area. Combination of BA 200 ppm × pinching (63.97 cm^2) observed maximum leaf area followed by interactions of BA 300 ppm × pinching, BA 100 ppm × no pinching, BA 250 ppm × no pinching and which was significant to all other combinations. While, control × no pinching observed minimum leaf area.

Table 4.18: Effect of BA and pinching on leaf area and leaf area index in phlox

Treatment	**Leaf area (cm^2)**	**Leaf area index**
No pinching	49.14	0.79
Pinching	49.91	0.91
C.D. at 5%	0.69	0.12
Control	36.37	0.44
BA 50ppm	45.52	0.72
BA 100ppm	47.68	0.73
BA 150 ppm	48.15	1.16
BA 200ppm	57.79	1.10
BA 250ppm	52.93	0.94
BA 300ppm	58.21	0.87
C.D. at 5%	1.30	0.23
Interaction (T×P)		
Control × No pinching	34.43	0.44
BA 50 ppm × No pinching	41.17	0.54
BA 100 ppm × No pinching	56.50	0.87
BA 150 ppm × No pinching	47.93	1.05
BA 200 ppm × No pinching	51.60	0.88
BA 250 ppm × No pinching	56.30	0.98
BA 300 ppm × No pinching	56.02	0.80
Control × Pinching	38.30	0.44
BA 50 ppm × Pinching	49.87	0.89
BA 100 ppm × Pinching	38.87	0.59
BA 150 ppm × Pinching	48.37	1.28
BA 200 ppm × Pinching	63.97	1.33
BA 250 ppm × Pinching	49.57	0.91
BA 300 ppm × Pinching	60.40	0.95
C.D. at 5%	1.83	0.32

4.2.1.12 Leaf area index

A perusal of data in Table 4.18 and described in Fig. 4.22 indicates the effect of benzyl adenine and pinching on leaf area index. An effect of BA, pinching and their interaction on leaf area index was found to be significant. Treatment pinching resulted maximum leaf area index (0.91) than no pinching. Treatment BA 150 ppm (1.16) showed maximum leaf area index which was at par with BA 200 ppm and significant to all other treatments. However, minimum leaf area index was obtained with control. Interaction of BA 200 ppm × pinching (1.33) obtained maximum leaf area index which was at par with interactions of BA 150 ppm × pinching, BA 150 ppm × no pinching and which was significant to all other combinations. While, minimum leaf area index was reported with control × no pinching.

4.2.1.13 Number of leaves/plant.

Table 4.19 and Fig 4.23 showed that different concentrations of BA and pinching resulted in significant variation in the number of leaves/plant but their interactions failed to generate any significant influence on number of leaves/plant. Treatment pinching showed maximum number of leaves (534.67) compared to no pinching. Maximum number of leaves/plant (597.58) was noted with treatment BA 300 ppm which was at par with treatment BA 200 ppm, BA 150 ppm and significant to all other treatment. The effect of interaction BA with pinching was reported non-significant.

Table 4.19: Effect of BA and pinching on number of leaves/plant in phlox

Treatment	**Number of leaves / plants**
No pinching	476.79
Pinching	534.67
C.D. at 5%	92.77
Control	365.67
BA 50 ppm	470.33
BA 100 ppm	454.83
BA 150 ppm	551.25
BA 200 ppm	567.17
BA 250 ppm	533.25
BA 300 ppm	597.58
C.D. at 5%	49.59
Interaction (T×P)	
Control × No pinching	386.83
BA 50 ppm × No pinching	399.00
BA 100 ppm × No pinching	466.67
BA 150 ppm × No pinching	505.83
BA 200 ppm × No pinching	504.00
BA 250 ppm × No pinching	514.50
BA 300 ppm × No pinching	560.67
Control × Pinching	344.50
BA 50 ppm × Pinching	541.67
BA 100 ppm × Pinching	443.00
BA 150 ppm × Pinching	596.67
BA 200 ppm × Pinching	630.33
BA 250 ppm × Pinching	552.00
BA 300 ppm × Pinching	634.50
C.D. at 5%	NS

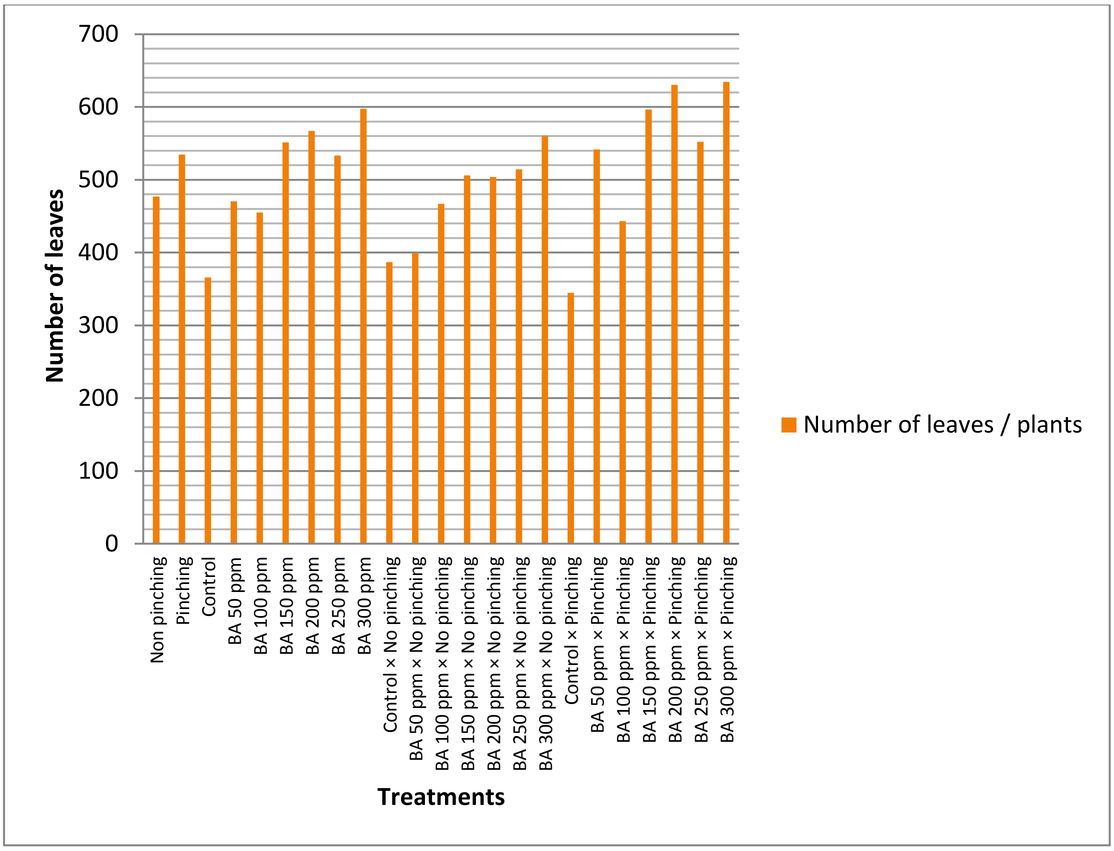

Fig. 4.23 Effect of BA and pinching on number of leaves/plant in phlox.

4.2.2 Effect of BA and pinching on flowering parameter in Phlox

4.2.2.1 Days to bud initiation

The data regarding the response of various concentrations of BA, pinching and their interaction on days to bud initiation in phlox is presented in Table 4.20 and graphically illustrated in Fig. 4.24. Effect of BA, pinching and their interactions on days to bud initiation was found to be statistically significant. Pinching exhibited maximum days to bud initiation (72.19 days) which was significant to no pinching. Among various doses of BA, minimum days to bud initiation was reported with BA 150 ppm (66.75 days) followed by BA 250 ppm, BA 200 ppm and was significant to all other treatments. However, control showed maximum days to bud initiation. Among different interactions maximum days to bud initiation was recorded with interaction of BA 50 ppm × pinching (77.00 days) which was at par with interaction of control × pinching and significant to all other combinations. However, minimum days to bud initiation was observed with interaction of BA 50 ppm × no pinching.

4.2.2.2 Bud diameter

The bud diameter was significantly influenced by various levels of BA and their interaction with pinching (Table 4.20 and Fig. 4.24). However, pinching alone failed to exert any significant variations. Among BA treatments, maximum bud diameter was recorded with treatment BA 150 ppm (3.64 mm) followed by treatments BA 50 ppm, BA 300 ppm which was significant to all other treatment. While, minimum bud diameter was noted with treatment BA 200 ppm. Maximum bud diameter was noted with interaction of BA 150 ppm × pinching (3.77 mm) followed by interactions of BA 50 ppm × pinching, BA 150 ppm × no pinching and significant to all other interactions. While, minimum bud diameter was observed with interaction of BA 200 ppm × no pinching.

Table 4.20: Effect of BA and pinching on days to bud initiation and bud diameter in phlox

Treatment	Days to bud initiation (Days)	Bud diameter (mm)
No pinching	69.14	3.36
Pinching	72.19	3.4
C.D. at 5%	1.13	NS
Control	75.33	3.34
BA 50ppm	71.92	3.46
BA 100ppm	71.08	3.29
BA 150 ppm	66.75	3.64
BA 200ppm	69.58	3.24
BA 250ppm	69.50	3.29
BA 300ppm	70.50	3.41
C.D. at 5%	2.12	0.11
Interaction (T×P)		
Control × No pinching	74.00	3.36
BA 50 ppm × No pinching	66.33	3.34
BA 100 ppm × No pinching	68.67	3.38
BA 150 ppm × No pinching	67.17	3.51
BA 200 ppm × No pinching	68.67	3.22
BA 250 ppm × No pinching	69.00	3.34
BA 300 ppm × No pinching	69.67	3.35
Control × Pinching	76.67	3.32
BA 50 ppm × Pinching	77.00	3.57
BA 100 ppm × Pinching	73.50	3.21
BA 150 ppm × Pinching	67.33	3.77
BA 200 ppm × Pinching	70.50	3.26
BA 250 ppm × Pinching	70.00	3.24
BA 300 ppm × Pinching	71.33	3.46
C.D. at 5%	2.99	0.16

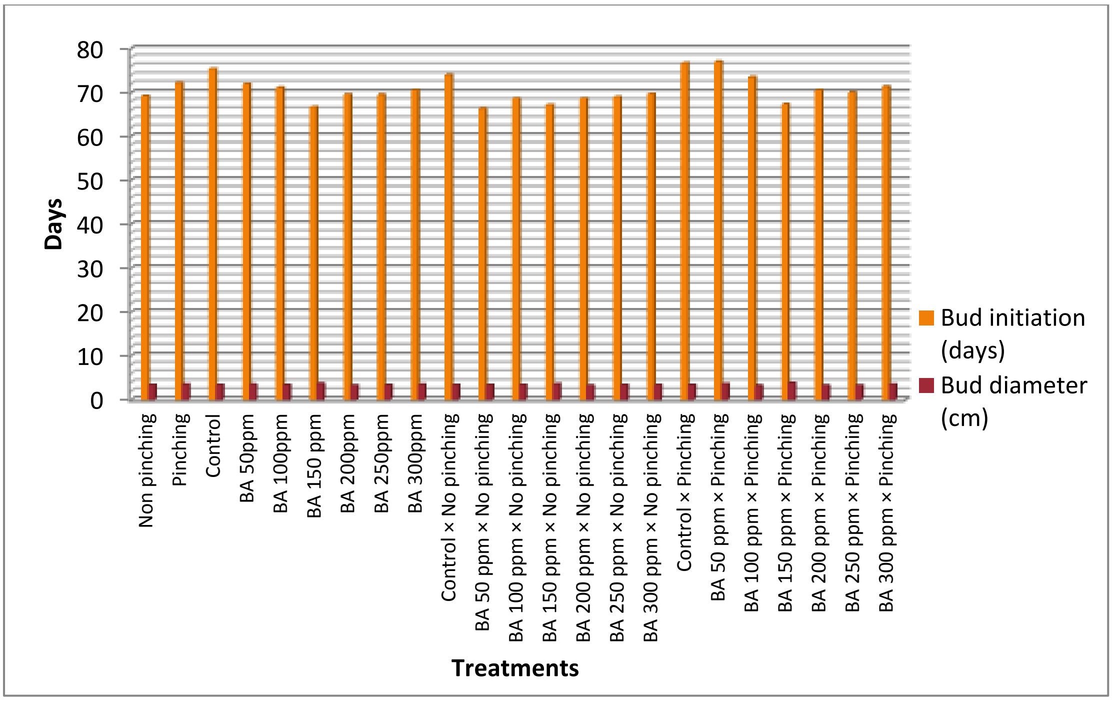

Fig. 4.24: **Effect of BA and pinching on days to bud initiation and bud diameter in phlox**

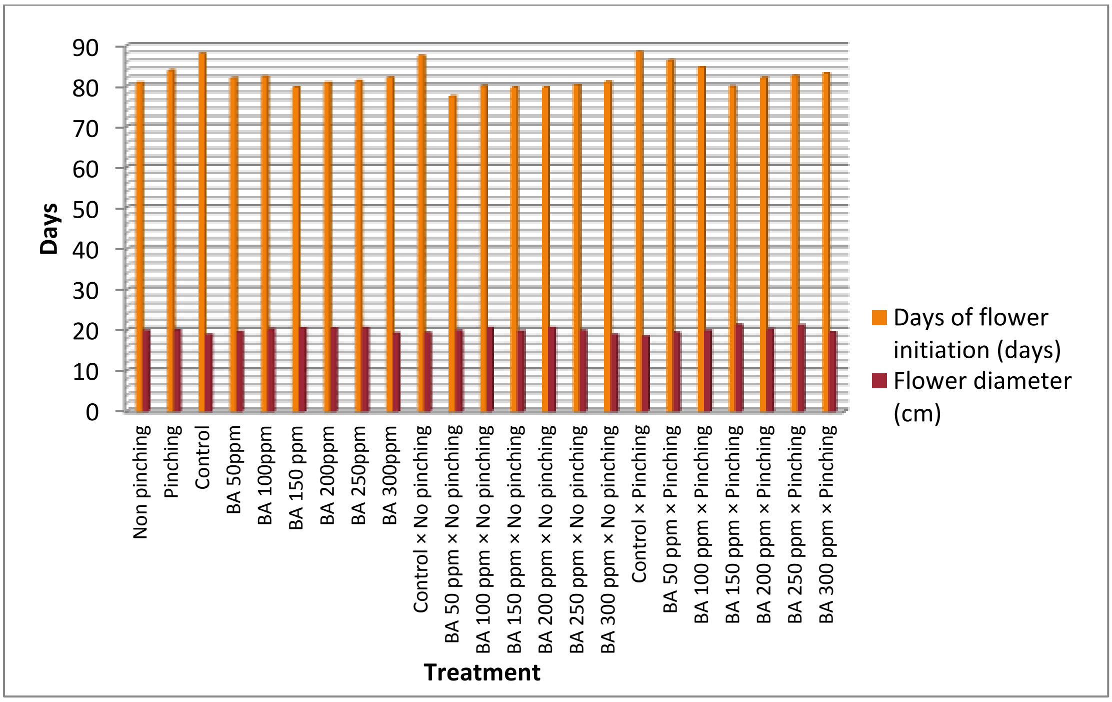

Fig. 4.25: **Effect of BA and pinching on days to flower initiation and flower diameter in phlox**

4.2.2.3 Days to flower initiation

Data regarding days to flower initiation is presented in Table 4.21 and graphically outlined in Fig. 4.25 was found significantly influenced due to by different levels of BA, pinching and their combinations in phlox. Maximum days to flower initiation (83.86 days) was observed with treatment pinching which was significantly higher to treatment no pinching. Early flowering was recorded with treatment BA 150 ppm (79.75 days) which was at par with treatments BA 200 ppm, BA 250 ppm, BA 50 ppm BA 300 ppm, BA 100 ppm and significant to all other treatments. Whereas, maximum days to flower initiation was observed with control. Minimum days to flower initiation was recorded with interaction of BA 50 ppm × no pinching (77.50 days) which was at par with interactions of BA 150 ppm × no pinching, BA 200 ppm × no pinching, BA 150 ppm × pinching, BA 50 ppm × no pinching, BA 250 × no pinching, BA 300 × no pinching and which was significant to other interactions. While, maximum days to flower initiation was observed with combination of control × pinching.

4.2.2.4 Flower diameter

It is depicted in Table 4.21 and Fig. 4.25 that different level of BA, pinching and their interactions significantly influenced flower diameter in phlox. Pinching treatment showed maximum flower diameter (19.97 mm) compared to treatment no pinching. Among various treatment BA, BA 250 ppm recorded maximum flower diameter (20.53 mm) which was at par with BA 150 ppm, BA 200 ppm and significant to all other treatments. While, minimum flower diameter was recorded with control. Interaction of BA 150 ppm × pinching (21.28 mm) reported maximum flower diameter which was at par with interaction of BA 250 ppm × pinching and significant to all other combinations. However, minimum flower diameter was noted with interaction of control × pinching.

Table 4.21: Effect of BA and pinching on days to flower initiation and flower diameter in phlox.

Treatment	Days of flower initiation (DAT)	Flower diameter (mm)
No pinching	80.79	19.83
Pinching	83.86	19.97
C.D. at 5%	1.40	0.14
Control	88.00	18.89
BA 50ppm	81.92	19.60
BA 100ppm	82.33	20.21
BA 150 ppm	79.75	20.48
BA 200ppm	80.83	20.41
BA 250ppm	81.33	20.53
BA 300ppm	82.08	19.18
C.D. at 5%	2.62	0.27
Interaction (T×P)		
Control × No pinching	87.50	19.35
BA 50 ppm × No pinching	77.50	19.83
BA 100 ppm × No pinching	80.00	20.61
BA 150 ppm × No pinching	79.67	19.68
BA 200 ppm × No pinching	79.69	20.62
BA 250 ppm × No pinching	80.17	19.83
BA 300 ppm × No pinching	81.00	18.87
Control × Pinching	88.50	18.42
BA 50 ppm × Pinching	86.33	19.38
BA 100 ppm × Pinching	84.67	19.81
BA 150 ppm × Pinching	79.83	21.28
BA 200 ppm × Pinching	82.00	20.21
BA 250 ppm × Pinching	82.50	21.22
BA 300 ppm × Pinching	83.17	19.50
C.D. at 5%	3.77	0.38

4.2.2.5 Fresh weight of flower

The data pertaining to fresh weight of flower as significantly influenced by different concentrations of BA, pinching and their interactions is given in Table 4.22 and visually depicted in Fig. 4.26. Pinching treatment resulted maximum fresh weight of flower (1.19 g) which was statistically significant to no pinching. Among various BA treatment, maximum fresh weight of flower (1.76 g) was observed with treatment BA 150 ppm followed by BA 250 ppm, BA 300 ppm and significant to all other treatments. Whereas, minimum fresh weight of flower was reported with control. Interaction of BA 150 ppm × pinching (2.30 g) measured maximum fresh weight of flower followed by BA 150 ppm × no pinching and significant to all other interactions. While, minimum fresh weight of flower was noted with interaction of control × no pinching.

4.2.2.6 Dry weight of flower

The data presented on Table 4.22 and depicted in Fig. 4.26 revealed that dry weight of the flower was found influenced significantly due to the effect of BA and its interaction with pinching. However, pinching failed to exert any significant effect on dry weight of flower. Among various BA treatment, maximum dry weight of flower was noted with BA 150 ppm (0.24 g) followed by BA 50 ppm, BA 250 ppm and significant to all other treatments. Whereas, minimum dry weight of flower was reported with control (0.16 g). Maximum dry weight was reported with interaction of BA 150 ppm × pinching (0.26 g) followed by interaction of BA 250 ppm × no pinching , BA 150 ppm × no pinching and significant to all other interaction. While, minimum dry weight of flower was observed with interaction of control × pinching.

Table 4.22: Effect of BA and pinching on fresh and dry weight of flower in phlox

Treatment	Fresh weight of flower (g)	Dry weight of flower (g)
No pinching	1.04	0.187
Pinching	1.19	0.189
C.D. at 5%	0.09	NS
Control	0.98	0.16
BA 50ppm	0.99	0.19
BA 100ppm	0.98	0.18
BA 150 ppm	1.76	0.24
BA 200ppm	1.00	0.18
BA 250ppm	1.08	0.19
BA 300ppm	1.03	0.18
C.D. at 5%	0.18	0.02
Interaction (T×P)		
Control × No pinching	0.93	0.17
BA 50 ppm × No pinching	1.04	0.20
BA 100 ppm × No pinching	0.98	0.18
BA 150 ppm × No pinching	1.21	0.21
BA 200 ppm × No pinching	0.94	0.16
BA 250 ppm × No pinching	1.19	0.22
BA 300 ppm × No pinching	1.02	0.17
Control × Pinching	1.04	0.15
BA 50 ppm × Pinching	0.95	0.19
BA 100 ppm × Pinching	0.99	0.17
BA 150 ppm × Pinching	2.30	0.26
BA 200 ppm × Pinching	1.06	0.20
BA 250 ppm × Pinching	0.98	0.16
BA 300 ppm × Pinching	1.03	0.19
C.D. at 5%	0.25	0.03

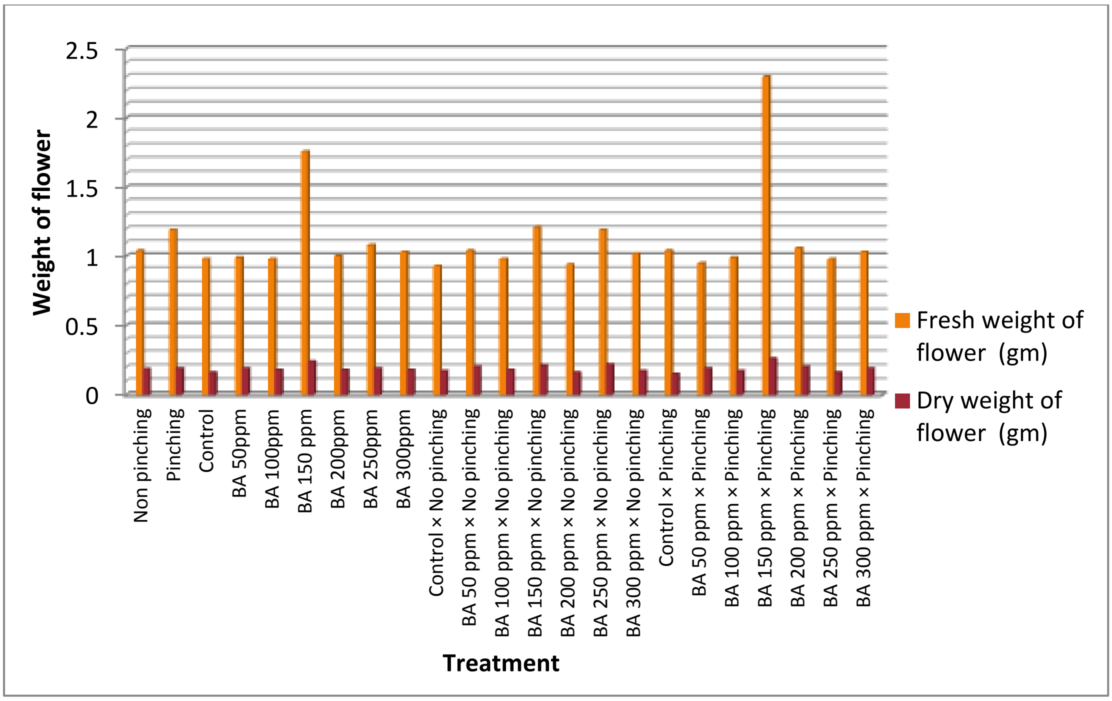

Fig. 4.26: Effect of BA and pinching on fresh and dry weight of flower in phlox

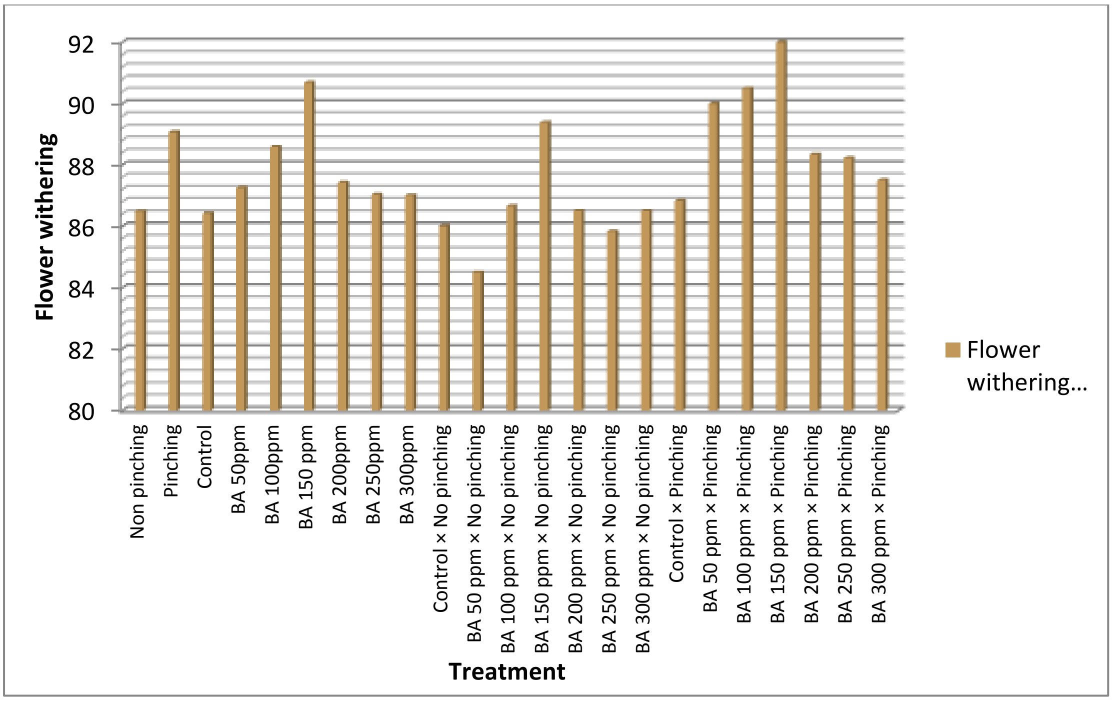

Fig. 4.27: Effect of BA and pinching on days to flower withering in phlox.

4.2.2.7 Days to flower withering

The data regarding the effect of BA, pinching and their interactions on days to flower withering is presented in Table 4.23 and illustrated graphically in Fig. 4.27. Minimum day to flower withering (86.48 days) was recorded with no pinching which was significant to pinching (89.06 days). Among different levels BA treatment, maximum day to flower withering was recorded with treatment BA 150 ppm (90.69 days) followed by BA 100 ppm, BA 200 ppm and significant all of the treatments. While, minimum days to flower withering was observed with control. Effect of interaction of BA and pinching resulted also had significant influenced on days to flower withering. Interaction of BA 150 ppm × pinching (92.00 days) showed maximum days to flower withering followed by interactions of BA 100 ppm × pinching, BA 50 ppm × pinching and significant to all other combinations. While, minimum days to flower withering was observed with interaction of BA 50 ppm × no pinching.

4.2.2.8 Number of flowers/plant

The significant effect of different concentrations of BA, pinching and their combinations on number of flowers/plant is Table 4.23 and visually depicted in Fig. 4.28. Pinching treatment resulted maximum number of flowers/plant (241.24) which was significantly higher to no pinching. Maximum number of flowers/plant was produced with treatment BA 200 ppm (244.89) which was at par with BA 250 ppm, BA 300 ppm and significant to all other treatments. While, minimum number of flowers/plant was recorded with control. Maximum number of flowers/plants was reported with interaction of BA 300 ppm × pinching (268.33) which was at par with interactions of BA 200 ppm × pinching, BA 250 ppm × pinching, BA 150 ppm × pinching and significant to all other interactions. However, minimum number of flowers/plant was obtained with interaction of control × no pinching.

Table 4.23: Effect of BA and pinching on days to flower withering and number of flowers/plant in phlox

Treatment	**Flower withering (Days)**	**Number of flowers/plant**
No pinching	86.48	198.82
Pinching	89.06	241.25
C.D. at 5%	0.33	3.95
Control	86.42	184.78
BA 50ppm	87.25	198.97
BA 100ppm	88.58	192.17
BA 150 ppm	90.69	236.75
BA 200ppm	87.42	244.89
BA 250ppm	87.03	243.09
BA 300ppm	87.00	239.58
C.D. at 5%	0.62	7.38
Interaction (T x P)		
Control × No pinching	86.00	159.56
BA 50 ppm × No pinching	84.50	173.67
BA 100 ppm × No pinching	86.66	193.00
BA 150 ppm × No pinching	89.39	211.00
BA 200 ppm × No pinching	86.50	221.66
BA 250 ppm × No pinching	85.83	222.00
BA 300 ppm × No pinching	86.50	210.83
Control × Pinching	86.83	210.00
BA 50 ppm × Pinching	90.00	224.28
BA 100 ppm × Pinching	90.50	191.33
BA 150 ppm × Pinching	92.00	262.50
BA 200 ppm × Pinching	88.33	268.11
BA 250 ppm × Pinching	88.22	264.17
BA 300 ppm × Pinching	87.50	268.33
C.D. at 5%	0.88	10.44

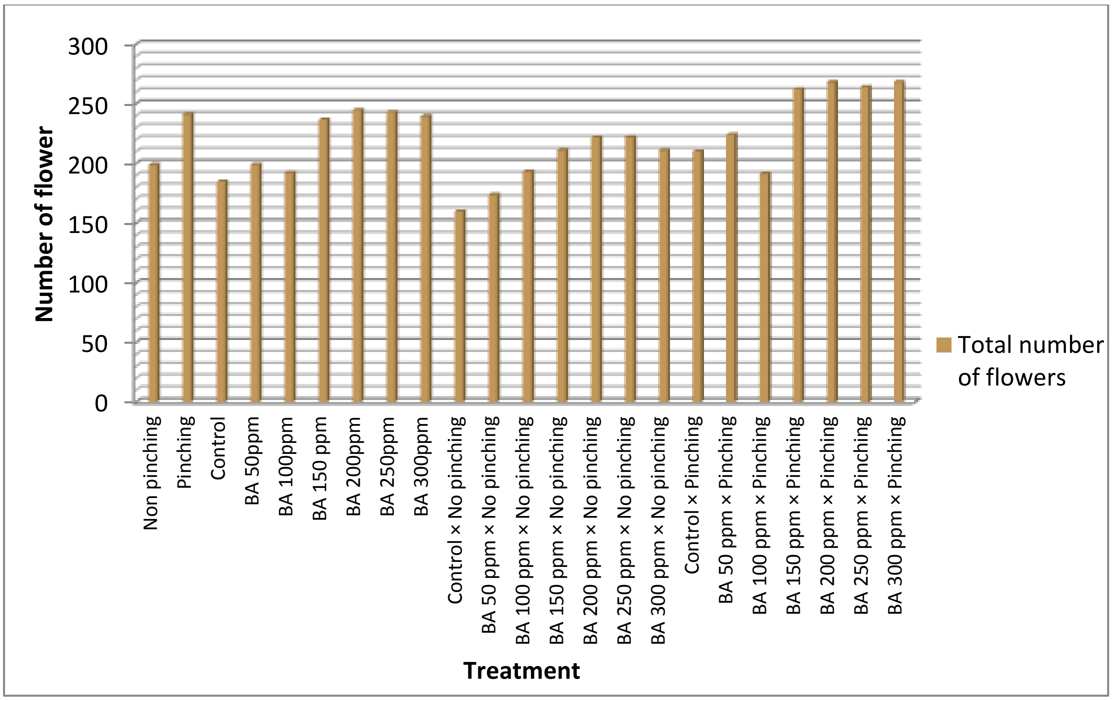

Fig. 4.28 Effect of BA and pinching on number of flower/plant in phlox

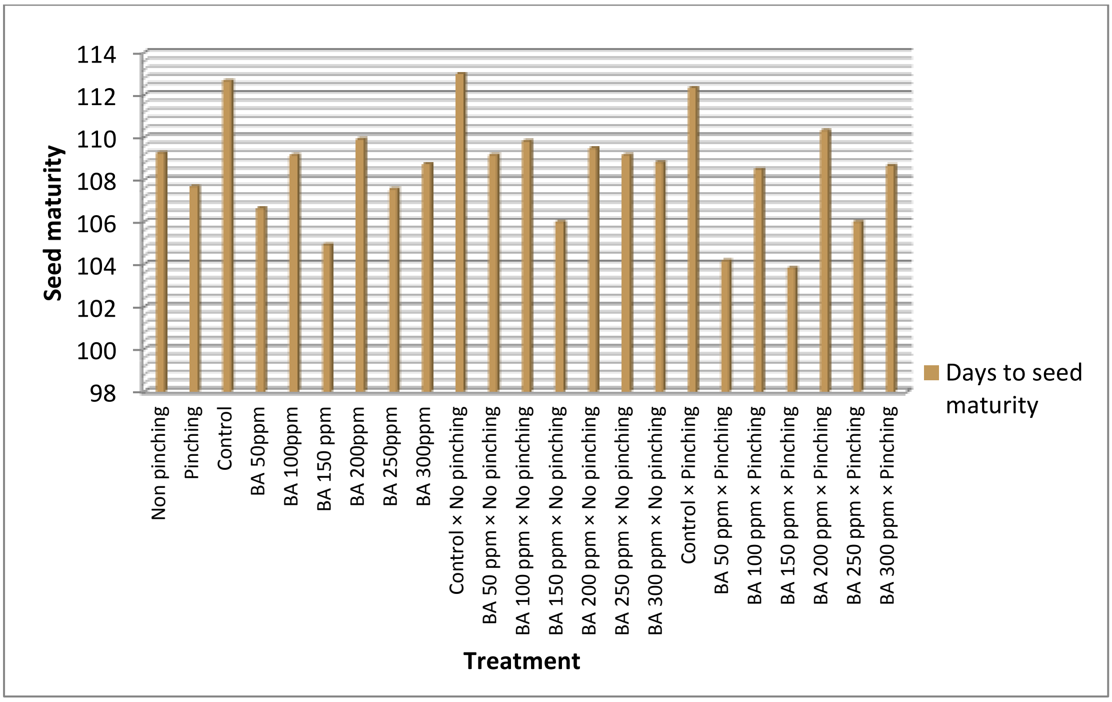

Fig. 4.29: Effect of BA and pinching on days to seed maturity in phlox

4.2.3 Effect of BA and pinching on seed characters

4.2.3.1 Days to seed maturity

The data regarding days to seed maturity is presented in Table 4.24 and illustrated graphically in Fig. 4.29 indicated that various concentrations of BA, pinching and their interactions resulted significant influenced on days to seed maturity in phlox. Minimum days to seed maturity was recorded with pinching (107.69 days) which was significant to no pinching (109.27 days). Maximum days to seed maturity was recorded with control followed by BA 200 ppm, BA 100 ppm, BA 300 ppm and significant all other treatments. While, minimum days to seed maturity was observed with BA 150 ppm. Interaction between BA × pinching revealed that maximum days to seed maturity (112.33 days) was noticed with interaction of control × pinching and significant to all other interactions. While, early seed maturity was reported with interaction of BA 150 ppm × pinching.

4.2.3.2 Seed yield/plant

A perusal of data presented in Table 4.24 and depicted in Fig. 4.30 indicated that significant effects of BA, pinching and their interactions resulted significant influenced on seed yield/plant. Pinching treatment obtained maximum seed yield/plant (2.76 g) which was significant to no pinching. Foliar spray of BA 200 ppm (3.41 g) resulted maximum seed yield/plant which was at par with BA 100 ppm, BA 300 ppm and significant to all other treatments. Whereas, minimum seed yield/plant was noted with control. Interaction of BA 200 ppm and pinching recorded maximum seed yield/plant (4.28 g) followed by interactions of BA 100 ppm × no pinching, BA 300 ppm × pinching, BA 300 ppm × no pinching was significant higher than to all other interaction. Whereas, minimum seed yield/plant was reported with interaction of BA 250 ppm × no pinching.

Table 4.24: Effect of BA and pinching on days to seed maturity and seed yield/plant in phlox

Treatment	Days to seed maturity (Days)	Seed yield/plant (g)
No pinching	109.27	2.64
Pinching	107.69	2.76
C.D. at 5%	0.89	0.12
Control	112.67	2.13
BA 50ppm	106.67	2.56
BA 100ppm	109.17	3.24
BA 150 ppm	104.92	2.30
BA 200ppm	109.92	3.41
BA 250ppm	107.58	2.19
BA 300ppm	108.75	3.08
C.D. at 5%	1.66	0.22
Interaction (T×P)		
Control × No pinching	113.00	2.16
BA 50 ppm × No pinching	109.17	2.51
BA 100 ppm × No pinching	109.83	3.85
BA 150 ppm × No pinching	106.00	2.52
BA 200 ppm × No pinching	109.50	2.53
BA 250 ppm × No pinching	109.17	1.81
BA 300 ppm × No pinching	108.83	3.08
Control × Pinching	112.33	2.09
BA 50 ppm × Pinching	104.17	2.62
BA 100 ppm × Pinching	108.50	2.62
BA 150 ppm × Pinching	103.83	2.08
BA 200 ppm × Pinching	110.33	4.28
BA 250 ppm × Pinching	106.00	2.58
BA 300 ppm × Pinching	108.67	3.08
C.D. at 5%	2.35	0.32

4.2.3.3 Seed yield/m^2

The data pertaining to seed yield/m^2 as significantly influenced due to various level of BA, pinching and their interactions have been presented in Table 4.25 and depicted in Fig. 4.30. Maximum seed yield/m^2 (4.54 g) was recorded with treatment pinching which was significantly higher than no pinching. Maximum seed yield/m^2 was reported with BA 200 ppm (5.63 g) followed by BA 150 ppm, BA 250 ppm and significant to all other treatments. While, minimum seed yield/m^2 was registered with control. Among various interactions, maximum seed yield/m^2 was recorded with interaction of BA 200 ppm × pinching (6.27 g) which was at par with interaction of BA 300 ppm × pinching and significant to all other interactions. However, minimum seed yield/m^2 was observed with interaction of control × no pinching.

4.2.3.4 Test weight

The data presented in Table 4.25 and graphically outlined in Fig. 4.31 revealed that dry weight of the flower was influenced significantly due to the effects of BA and its interaction with pinching. However, treatment pinching failed to exert significant effect on test weight. Among various BA treatment, maximum test weight was recorded with treatment BA 200 ppm (3.50 g) followed by BA 300 ppm, BA 250 ppm, and significant to all other treatments. Minimum test weight was noted with control. Maximum test weight was reported with interaction of BA 200 ppm × pinching (3.61 g) which was at par with interaction of BA 250 ppm × no pinching and significant to all other interactions. However, minimum test weight was reported with interaction of BA 100 ppm × no pinching.

Table 4.25: Effect of BA and pinching on seed yield per plant and test weight in phlox

Treatment	**Seed yield/m^2 (g)**	**Test weight (g)**
No pinching	3.74	2.82
Pinching	4.54	2.84
C.D. at 5%	0.30	NS
Control	3.31	2.49
BA 50ppm	3.98	2.51
BA 100ppm	3.47	2.68
BA 150 ppm	4.63	2.51
BA 200ppm	5.63	3.50
BA 250ppm	4.04	2.84
BA 300ppm	3.93	3.29
C.D. at 5%	0.55	0.10
Interaction (T×P)		
Control × No pinching	2.62	2.73
BA 50 ppm × No pinching	3.61	2.42
BA 100 ppm × No pinching	4.18	2.13
BA 150 ppm × No pinching	2.98	2.38
BA 200 ppm × No pinching	5.29	3.39
BA 250 ppm × No pinching	3.84	3.55
BA 300 ppm × No pinching	3.64	3.14
Control × Pinching	4.35	2.25
BA 50 ppm × Pinching	4.00	2.59
BA 100 ppm × Pinching	2.75	3.21
BA 150 ppm × Pinching	4.21	2.64
BA 200 ppm × Pinching	6.27	3.61
BA 250 ppm × Pinching	4.23	2.14
BA 300 ppm × Pinching	5.98	3.43
C.D. at 5%	0.78	0.14

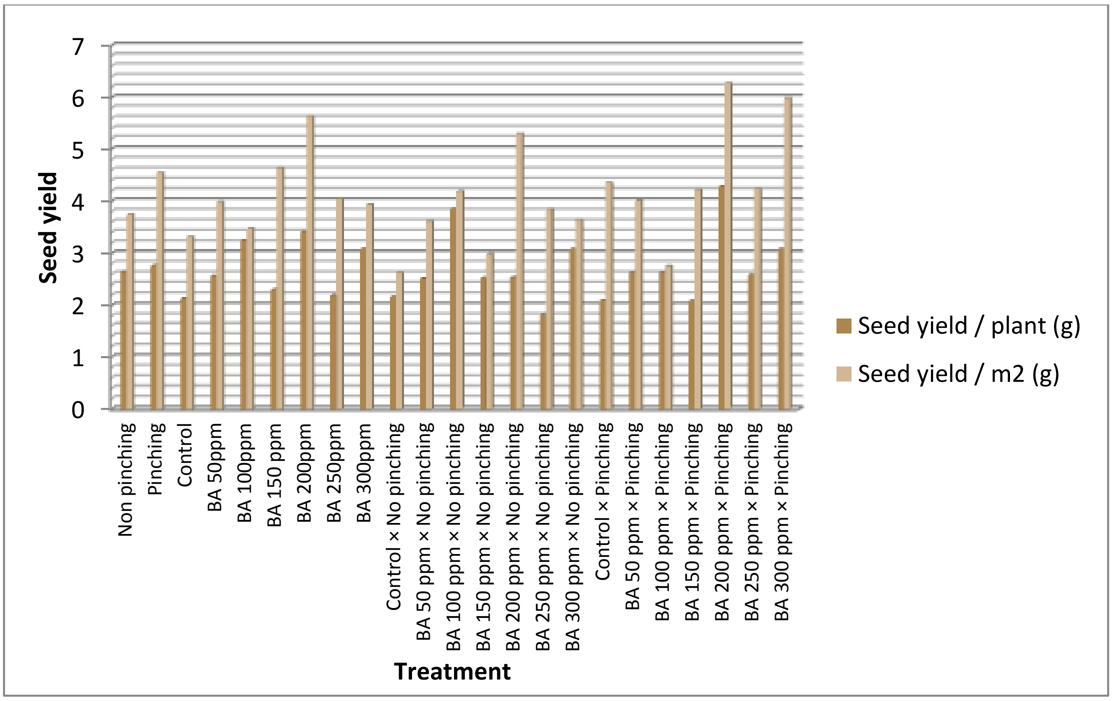

Fig. 4.30: **Effect of BA and pinching on seed yield per plant and seed yield/meter^2 in phlox**

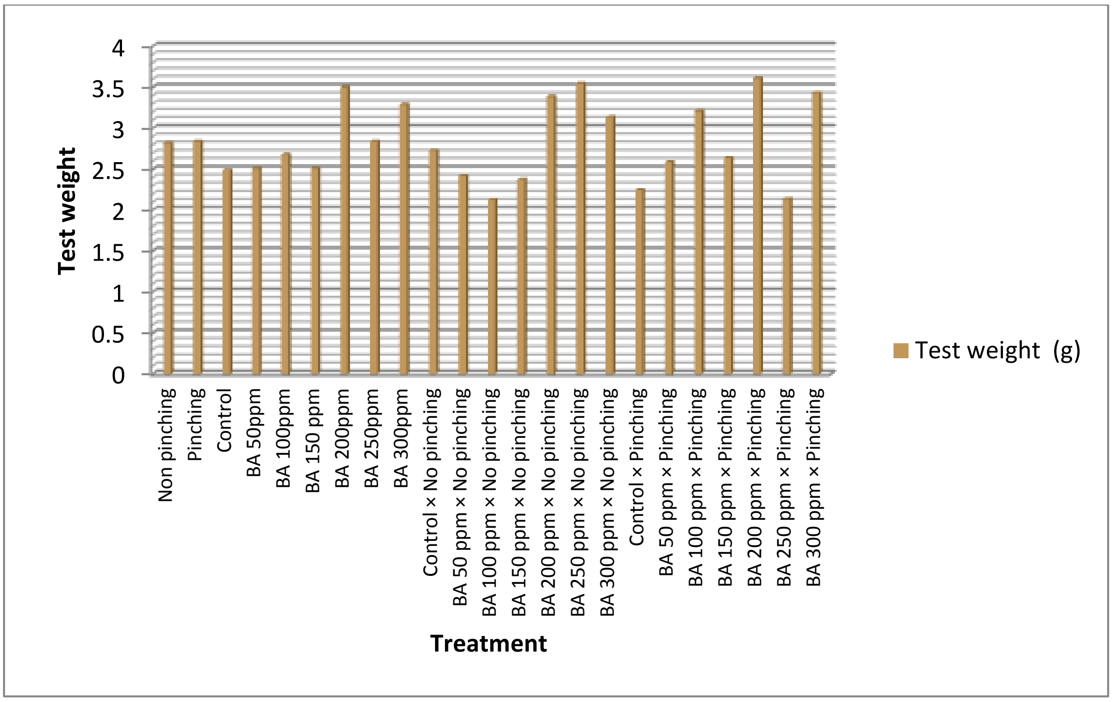

Fig. 4.31: Effect of BA and pinching on test weight in phlox

Chapter V

DISCUSSION

The present investigation entitled "**Effect of BA and pinching on growth, flowering and seed yield parameters in calendula and phlox,"** was conducted during the year 2021-22, at the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. This chapter deals with the analysis and discussion of the results of this investigation. Many significant variations were observed in the previous chapters due to the influence of BA and pinching treatments which will be discussed below with the reference to relevant literature in their respective fields. The discussion is limited to the appropriate crop and theme, specifically how different treatments effect growth, flowering and seed yield parameters in calendula and phlox.

5.1 Experiment no: 1 Effect of BA and pinching on growth, flowering and seed yield parameters in calendula

5.1.1 Effect of BA and pinching on vegetative parameters

5.1.1.1 Plant height

Plant height at 60 DAT in calendula is significantly influenced due to different levels of pinching and BA but their interactions failed to exert any significant result. Maximum plant height was recorded with treatment no pinching, BA 150 ppm and interaction of BA 250 ppm × no pinching. At 90 DAT, plant height was significantly influenced by various concentration of BA, pinching and their interactions. Treatment BA 150 ppm, pinching and interaction of BA 250 ppm × pinching recorded maximum plant height. Pinching treatments resulted significantly dwarf plants as compared to no pinching. This could be because of the absence of the terminal growing part, which reduced plant height (Palekar *et al*., 2018). These results are corroborated with the findings of Palekar *et al*. (2018) in marigold and BA promotes cell elongation and division which increases plant height. This result is in agreement with Naji *et al.* (2015) in lilium and Matsumoto (2006) in orchid.

5.1.1.2 Number of primary branches/plant

Number of primary branches were significantly influenced due to BA, pinching and their interactions. Maximum primary branches (60 & 90 DAT) was noted with treatment BA 250 ppm, pinching and interaction of BA 250 ppm × pinching and it could be attributed to the synergistic effects of applications of higher doses of benzyl adenine and pinching. The might be the result of apical dominance theory, which suggests that the production of more lateral buds results from the decrease of auxin production caused by the decapitation of shoots by pinching (Arora and Khanna, 1986). Exogenous applications of cytokines, and particularly BA, are known to increase plant biomass, particularly in terms of development and production of lateral buds that develop into primary branches. Similar results were reported by Khan *et al*. (2018) in marigold and Salve *et al*. (2016) in chrysanthemum.

5.1.1.3 Number of secondary branches/plant

The number of secondary branches per plant was significantly influenced by different concentrations of BA and its interaction with pinching. However, pinching treatment alone failed to exert any significant variation. Number of secondary branches/plant was reported maximum with treatment BA 150 ppm and interaction of BA 150 ppm × pinching. The increase in secondary branch number per plant due to BA and pinching appears to enhanced cell division, cell expansion, elimination of apical dominance and encouragement of lateral bud development (Jena, 2021). These results are in conformity with the findings of Naik *et al*. (2004) and khan *et al*. (2018) in marigold and Salve *et al*. (2016) in chrysanthemum.

5.1.1.4 Plant spread

At 60 and 90 DAT, the results revealed that BA, pinching and their interactions had a significant effect on plant spread. At 60 days, treatment BA 150 ppm, pinching and interaction of pinching × BA 100 ppm recorded maximum plant spread. While, at 90 days, the maximum plant spread was reported with treatment BA 300 ppm, pinching and interaction of BA 200 ppm × pinching. The increase in plant spread caused by BA could be attributed to the stimulation of cell division and elongation, as well as an increase in cell wall flexibility. Pinching diminishes apical dominance and increases the number of lateral branches. Similar results were also reported by Salve *et al*. (2016) in chrysanthemum, Baskaran and Abirami (2017) in marigold.

5.1.1.5 Stem diameter

Various concentrations of BA, pinching levels and their interaction significantly influenced the stem diameter in calendula. Treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching reported maximum stem diameter. Exogenous application of BA has a significant impact on biomass accumulation. The increase in cell division and photosynthetic rate observed in plants sprayed with BA could be ascribed to cellular metabolic alterations, which could result in increased stem diameter (Mutui *et al*., 2003). Similar findings were obtained by Khan *et al*. (2018) in marigold and Nathan *et al*. (2019) in gomphrena.

5.1.1.6 Fresh weight of leaves

Various concentrations of BA and pinching treatments had a significant effect on fresh weight of leaves but their interactions failed to generate any significant influence on fresh weight of leaves. Maximum fresh weight of leaves was reported with treatment BA 150 ppm and treatment pinching. That might be because cytokines accelerate the movement and accumulation of food in leaves and enhance the fresh weight of the leaves/plant in response to BA (Petal *et al*., 2020). The above mentioned results regarding the effect of BA was reported by Ghait *et al*. (2020) in jasmine and khalil *et al*. (2021) in carnation.

5.1.1.7 Dry weight of leaves

The dry weight of the leaves was significant due to effect of BA, pinching level and their combinations. Maximum dry weight of leaves was observed with control, pinching and combination of control × pinching. These results are collaborated with the findings of Nain *et al*. (2017) in marigold.

5.1.1.8 Leaf area

A cursory investigation indicated that significant influenced of BA concentrations, pinching and their interactions on leaf area in calendula. The maximum leaf area was noted with treatment BA 150 ppm, pinching and interaction of BA 200 ppm × pinching. Increased leaf area might be attributed to thicker mesophyll tissues in leaves, which are related with higher chlorophyll content, making the leaves photosynthesis more active for longer durations, resulting in increased carbohydrate production (Ramy *et al.*, 2019). Similar effect was recorded by Salve *et al*. (2016) in chrysanthemum.

5.1.1.9 Leaf area index

The result of the leaf area index is significantly influenced by BA and pinching. However, interaction of BA with pinching failed to exert any significant influence on leaf area index in calendula. Treatment BA 150 ppm and pinching showed maximum leaf area index. Present finding is citated by Mounika *et al*. (2019) in chrysanthemum.

5.1.1.10 Number of leaves/plant

The data reveals that number of leaves was found statistically significant due to the various concentrations of BA and pinching. However, interaction of BA with pinching failed to exert significant effect on number of leaves. Maximum number of leaves per plant was noticed with treatment 200 ppm BA and pinching. As a result, the number of leaves produced in pinching was more than in non-pinching since every shoot has the tendency to develop leaves for the synthesis of food reserves required by the plants for better growth and development (Prakash *et al*., 2016). Cytokines such as benzyl adenine stimulate vegetative proliferation while also increasing the number of leaves due to a rapid mitosis. These were further supported by Mounika *et al*. (2019), Hibbia *et al*. (2012) in chrysanthemum, Khobragade *et al*. (2012) in China aster.

5.1.2 Effect of BA and pinching on flowering parameters

5.1.2.1 Days to bud initiation

The days to bud initiation in calendula is significantly influenced due to BA concentration, pinching level and their interactions. Maximum days to bud initiation was reported with treatment BA 250, pinching and interaction of BA 250 ppm × pinching. The possible reasons for delayed bud initiation in the interaction of pinching and higher concentration of benzyl adenine could be ascribed to the fact that pinching delayed bud formation which was further increased with the application of BA (Ramy *et al.*, 2019). The longer time required for visible bud initiation might be due to delay in auxin transport in basipetal order from meristematic branches to the branches bearing floral buds. Similar finding were supported by Singh and Bala (2020) and Jena *et al*. (2021) chrysanthemum.

5.1.2.2 Bud diameter

The data pertaining to the influenced of various concentrations of BA, pinching and their combined treatments was significantly on bud diameter. Maximum bud diameter was found with treatment BA 150 ppm, pinching and interaction of BA 150 ppm × pinching. The fact that BA and pinching inhibited cell division in the meristemic region, inhibiting main axis expansion and encouraging lateral buds via increased metabolite translocation to buds, could explain the increase in bud diameter. Similar effect was recorded by Salve *et al*. (2016) in chrysanthemum.

5.1.2.3 Days to flower initiation

The days to flower initiation in calendula is significantly influenced due to BA, pinching and their interactions. Maximum days to flower initiation was recorded with treatment BA 150 ppm, pinching and interaction of BA 150 ppm × pinching. Mechanisms for the delay in flowering after pinching interaction with BA application might include development of more laterals at the expense of apical dominance (Rajput *et al.*, 2020) and further catalyzing of vegetative growth of plants as a result of enhanced mitosis activity due to higher BA concentration. Similar results have also been obtained by Pathania *et al*. (2000) in sim carnation, Phetpradap *et al*. (1994) in dahlia.

5.1.2.4 Flower diameter

The data reveals that different levels of BA, pinching and their interactions with pinching had a significant effect on flower diameter. It was observed that maximum flower diameter was reported with interaction of BA 150 ppm × pinching, BA 150 ppm and pinching. This might be because BA is a cytokinine which has been shown to increase the rate of mitosis in certain plant cells. The elimination of apical dominance resulted in pinching. These finding also supported by Singh and Bala (2020), Singh and Baboo (2003) in chrysanthemum.

5.1.2.5 Peduncle length

The data pertaining to peduncle length as significantly influenced by different concentration of BA, pinching and their interaction. Treatments BA 200 ppm, pinching and their interaction of BA 200 ppm × no pinching resulted maximum peduncle length. The simulative effect of BA was enhanced cell division and cell extension, which might be the reason for the maximum peduncle length. Similar results were reported by Jindal *et al*. (2018) and Grawal *et al*. (2004) in chrysanthemum.

5.1.2.6 Days to flower withering

The data regarding with the effect of BA, pinching and their interactions on days to flower withering was statistically significant The maximum days to flower withering was obtained with treatment BA 50 ppm, pinching and their interaction of BA 50 ppm × pinching. The interaction could be related to the fact that BA is a type of cytokinine, which in general increases plant development in terms of biomass production, particularly the number of lateral branches that may become reproductive shoots in the course of time in succession (Rahman *et al*., 2021). As a result, this could eventually account for the prolonged length of flowering in comparison. The results respecting BA and pinching are in conformity with those reported by Jindal *et al*. (2018) in chrysanthemum.

5.1.2.7 Number of flowers/plant

The effect of different levels of BA, pinching and their combinations on number of flower/plant were found significant. Maximum number of flowers/plants was observed with treatment BA 200 ppm, pinching and combination of BA 300 ppm × pinching. The production of more flowers/plant in the interaction influences pinching and BA 300 ppm could be attributed to the fact that pinching prompted the effect of apical dominance, resulting in the translocation of more photosynthesis and flower stimulating hormones to the lateral shoots (Rathore *et al*., 2011), which was enhanced further by the application of BA for the induction of more floral buds, which later opened into flowers (Khalil *et al*., 2021). The results BA and pinching are in harmony with those attained by khalil *et al*. (2021) in carnation, Tomar *et al*. (2004) in marigold, Hibbia *et al*. (2012) in chrysanthemum and Petal and Arora (1986) in carnation.

5.1.2.8 Fresh weight of flower

The data pertaining to fresh weight of flower as significantly influenced by different concentration of BA, pinching and their interactions in calendula. Treatment BA 200 ppm, pinching and interactions of BA 150 ppm × pinching produced maximum fresh weight of flower. The increase in fresh weight of flower in treated plants might be due to the fact that BA improved plant efficacy in terms of photosynthetic activity, nutrient uptake and translocation and better assimilate partitioning into reproductive regions (Kasturi and Shkhar, 2017). Similar finding were supported by Rajput *et al*. (2020) in marigold.

5.1.2.9 Dry weight of flower

The data on dry weight of flower was significantly influenced by various concentrations of BA and pinching. However, interactions of pinching with BA failed to exert any significant variation. Maximum dry weight of flower was found with treatment BA 200 ppm and pinching. Similarly resulted was reported by of Nain *et al*. (2017) in marigold.

5.1.3 Effect of BA and pinching on seed characters

5.1.3.1 Days to seed maturity

Days to seed ripening was significant influenced due to treatments of BA, pinching and their interaction. Combination of BA × pinching revealed that maximum days to seed maturity was noticed with interaction of BA 250 ppm × pinching while, BA 200 ppm and pinching found maximum days to seed maturity. However, earlier seed maturity was reported that interaction of BA 50 ppm × no pinching. This delay in seed ripening induced by pinching and BA may be explained by the fact that during both processes, the physiologically mature portion of the shoot was removed, and the new shoot that emerged from the pinched plants took longer to become physiologically mature. Similarly, because BA promotes vegetative growth rather than flowering, flowering was delayed in plants that had been both pinched and BA sprayed. Similar results are also reported by Abdul Rahman *et al*. (2021) in dahlia

5.1.3.2 Seed yield/plant

Application of BA, pinching and their interactions significantly influenced seed yield/plant in calendula. Treatment BA 150 ppm, pinching and interaction of BA 200 ppm × pinching recorded maximum seed yield/plant. The BA and pinching interaction obtained the highest seed yield, which may be because BA significantly increased the number of branches and flowers (khalil *et al*., 2021). Maximum flower production results in a plant producing the maximum seeds. Same finding was reported by Amiri *et al*. (2021), Thakare *et al*. (2020) in chrysanthemum.

5.1.3.3 Seed yield/meter^2

Data pertaining to seed yield/m^2 was significantly influenced with different concentrations of BA, pinching levels and their interaction. The interaction of BA 150 ppm × pinching, BA 150 ppm and pinching registered maximum seed yield/meter^2. The flowers' size is increased by BA and pinching. Flower diameter was directly related to seed yield. Pinching is known to increase the rate of photosynthetic energy that is used to produce more flower-bearing branches and more seeds/flower (Rathore *et al*., 2011). Similar results are also shown by Rathore *et al*. (2011) in marigold.

5.1.3.4 Test weight

Results showed that various concentrations of BA, pinching and their interaction had a significant effect on seed test weight. Treatment BA 150 ppm, pinching and interactions of BA 250 ppm × pinching resulted maximum test weight of seed. When compared to no pinching, pinching increases the flower quality, the quantity of quality flowers produced and the number of seeds produced/flower. Quality seed parameters observed with BA, pinching and their interactions treatments may be related to the increase in photosynthetic area, which would then result in a higher photosynthetic rate, better assimilation and accumulation of more photosynthetic, which would then result in better seed development as revealed by a higher test weight (Mandal *et al*., 2018). Similar results have been obtained by Singh *et al*. (2015) in marigold.

5.1.3.5 Number of seeds/flower

Result from different concentration of BA along with pinching and their interaction had significant effect on number of seeds/flower. Maximum number of seeds/flower was reported with treatment BA 150 ppm, pinching and interaction of BA 100 ppm × no pinching. It is known that BA accumulation more photosynthetic material, which are used to produce more flower-bearing branches and more seeds/flower. Present research is in accordance with the study (Hammo, 2008) in nigella.

5.2 Experiment no. 2: Effect of BA and pinching on growth, flowering and seed yield parameters in phlox

5.2.1 Effect of BA and pinching on vegetative parameters

5.2.1.1 Plant height

Treatment of BA, pinching levels and their interactions at 60 and 90 DAT had a significant effect on plant height. Maximum plant height at 60 days was noted with treatment BA 200 ppm, no pinching and interaction of BA 200 ppm × no pinching. However, maximum plant height at 90 days was reported with combination of BA

200 ppm × no pinching, BA 200 ppm and pinching. The apical dominance and simultaneously positive impact of BA spray, which encourages strong longitudinal growth of the plant, are significant for the plant height measured significantly at its maximum in no pinching with BA 200 ppm treatment. The removal of the terminal growing portion that caused the plant's height to be inhibited may be the reason why plants under pinching treatments remained much dwarfed than those under no pinching (Palekar *et al*., 2018). A similar effect was recorded by Nain et al. (2017), Sunitha *et al*. (2007), Fatma (2017) in marigold and Mounika *et al*. (2019) in chrysanthemum.

5.2.1.2 Number of primary branches/plant

The number of primary branches/plant of phlox was recorded at 60 and 90 DAT under different concentrations of BA, pinching and their interactions were found to be significant. Maximum number of primary branches/plant at 60 days was noted with treatment BA 200 ppm, pinching and interaction of BA 300 ppm × pinching. While, maximum number of primary branches at 90 days was observed with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching. The removal of the apical portion of the plant and the application of BA may have increased the number of primary branches/plant (Ahmade, 2019). On the main branch, axillary buds were no longer suppressed by correlative inhibition brought on by the apical dominance phenomenon. These results are in close agreement with the findings of Rajput *et al*. (2020) in marigold.

5.2.1.3 Number of secondary branches/plant

The number of secondary branches/plant were significantly influenced due to BA, pinching and their interactions. Maximum number of secondary branches/plant was recorded with treatment BA 200 ppm, pinching and interactions of BA 200 ppm × pinching. The fact that the concentration of the phytohormone IAA decreased, encouraging the lateral buds to spread and develop new shoots and branches, may be connected to the fact that the elevation in cytokinin overcome apical dominance when the apical buds were pinched. Moreover, BA aids the plant in producing the much more secondary branches possible while pinching is fully exploited to encourage branching (Ahmade, 2019). Similar results were reported by Thumar *et al*. (2020) in chrysanthemum.

5.2.1.4 Plant spread

The result revealed that various concentrations of BA and pinching exhibited significant variation in plant spread at 60 DAT in phlox. Whereas interactions of BA with pinching failed to exert any significant influenced on plant spread. Treatment BA 250 ppm and pinching showed maximum plant spread. However BA, pinching and their interactions had a significant influenced on plant spread at 90 DAT. Maximum plant spread was recorded with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching. The increase in plant spread caused by BA could be attributed to the stimulation of cell division and elongation, as well as an increase in cell wall flexibility (Mandal *et al*., 2018). Pinching diminishes apical dominance and increases the number of lateral branches (Kumar *et al*., 2011). Present research finding similar to the Bhat and Shephered (2007) in marigold.

5.2.1.5 Stem diameter

Result indicated that BA and pinching as well as interaction showed significant effect on stem diameter. Treatment BA 200 ppm, pinching and BA 200 ppm × pinching observed maximum stem diameter. Exogenous application of BA has a significant impact on biomass accumulation. The increase in call division and photosynthetic rate observed in plants sprayed with BA could be ascribed to cellular metabolic alterations, which could result in increased stem diameter. The present investigation was in line with that of Thumar *et al*. (2020), Singh and Baboo (2003) in chrysanthemum, Nathan *et al*. (2019) in gomphrena.

5.2.1.6 Fresh and dry weight of leaf

The significant effects of BA, pinching and their interactions was observed on fresh and dry flower weight of leaf in phlox. Maximum fresh weight of leaves was noted with treatment BA 200 ppm, pinching and interaction of BA 200 ppm ×

pinching. Whereas, Maximum dry weight of leaves was recorded with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching. BA and pinching enhances the photosynthetic rate thereby increased in protein translocation from older tissue to younger ones resulted increased in fresh and dry weight of leaves (Ewais, 2012). Similar result also observed by Hawa *et al*. (2021), Ahmade (2019) in chrysanthemum.

5.2.1.7 Leaf area

The leaf area as influenced by various concentrations of BA, pinching levels and their interaction was significant. Maximum leaf area was found with BA 300 ppm, pinching and combination of BA 200 ppm × pinching. Increased leaf area might be attributed to thicker mesophyll tissues in leaves, which are related with higher chlorophyll content, making the leaves photosynthesis more active for longer durations, resulting in increased carbohydrate production (Mandal *et al*., 2018). The present finding is in conformity with the finding of Amiri *et al*. (2021) in chrysanthemum, Khobragade *et al*. (2012) in China aster.

5.2.1.8 Leaf area index

An effect of BA, pinching and their interaction on leaf area index was found to be significant. Treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching showed maximum leaf area index. This finding of leaf area index was in accordance with the results obtained by Khobragade *et al*. (2012) in China aster.

5.2.1.9 Number of leaves/plant

Different levels of pinching and BA led to a significant variation on the number of leaves per plant. However, interaction of pinching with BA failed to show any significant influence on number of leaves per plant. Maximum number of leaves/plant was observed with treatment BA 300 ppm and pinching. Number of leaves could be a result of photosynthetic moving to leaf auxiliary buds and the positive effects of BA, which led to the production of more leaves per plant (Jena *et* *al*., 2021). This observation is in line with Jena *et al*. (2021) in chrysanthemum, Kuamr and Singh (2003) in carnation.

5.2.2 Effect of BA and pinching on flowering parameter

5.2.2.1 Days to bud initiation

Effect of BA, pinching and their interaction on number of days to bud initiation was found to be statistically significant. Maximum days to bud initiation found with interaction of BA 50 ppm × pinching, control and no pinching. The delayed bud initiation with BA 50 ppm with pinching may be the result of pinching the apical bud which delayed the bud initiation process by hampering cell division in the lateral meristem and prevented the production of flower primordial in the meantime. A similar trend was observed previously in marigold (Singh *et al*., 2017)

5.2.2.2 Bud diameter

The bud diameter was significantly influenced by various levels of BA and their interaction with pinching. However, pinching alone filed to exert any significant variations. Maximum bud diameter was noted with treatment BA 150 ppm and interaction of BA 150 ppm × pinching. The fact that BA and pinching inhibited cell division in the meristemic region, inhibiting main axis expansion and encouraging lateral buds via increased metabolite translocation to buds, could explain the increase in bud diameter. A similar trend was observed previously in marigold (Singh *et al*., 2017)

5.2.2.3 Days to flower initiation

The days to flower initiation in phlox is significantly influenced due to BA, pinching and their interactions. Early flowering was recorded with treatment BA 150 ppm, no pinching and interaction of BA 50 ppm × no pinching It might be because new and emerging shoots typically require longer to become physiologically active and to encourage the formation of buds after the removal of apical buds during pinching and the application of BA, which eventually delayed the flowering (mandal *et al*., 2018) (Khan *et al*., 2018). These results are in close agreement with and finding of Gaidhani *et al*. (2020) in China aster.

5.2.2.4 Flower diameter

Flower diameter was significantly influenced by BA, pinching and their interaction. Treatment BA 250, pinching and BA 150 ppm × pinching reported maximum flower diameter. This might be because BA is a cytokinine which has been shown to increase the rate of mitosis in certain plant cells due to increase flower diameter. The elimination of apical dominance resulted in pinching. The similar results are quoted by Nain *et al*. (2017) in marigold, Hawa *et al*. (2021), Jindal *et al*. (2018) in chrysanthemum.

5.2.2.5 Fresh weight of flower

The data pertaining to fresh weight of flower was significantly influenced due to different concentrations of BA, pinching and interaction. Treatment BA 150 ppm, pinching and BA 150 ppm × pinching measured maximum fresh weight of flower. These results are in conformity with the findings of Fatma (2017) in marigold.

5.2.2.6 Dry weight of flower

Dry weight of the flower was found significant due to the effects of BA and its interaction with pinching. Pinching failed to exert significant effect on dry weight of the flower Maximum dry weight was reported with treatment BA 150 ppm and combination of BA 150 ppm × pinching. BA increase dry mass production by stimulates cell division and chlorophyll accumulation that help to activate photosynthesis and accumulation of dry matter (Khalil *et al*., 2021). Similar finding were observed by Fatma (2017) in marigold.

5.2.2.7 Days to flower withering

The data regarding the effect of BA, pinching and their interaction on days to flower withering (days) was observed statistically significant. Maximum day to flower withering was reported with treatment BA 150 ppm, pinching and BA 150 ppm × pinching. This might be because the apical portion of the plant was removed, spraying BA after pinching stimulated plant growth, produced profuse branches, and eventually the plant went back into vegetative phase, taking longer for new shoots to mature physiologically (Fatma, 2017). The results are in line with the findings of Sakar *et al*. (2003) in carnation.

5.2.2.8 Number of flowers/plant

The effect of different concentrations of BA, pinching and their combinations on number of flowers/plant was found significant. Maximum number of flower/plants was reported with BA 200 ppm, pinching and interaction of BA 300 ppm × pinching. Pinching and BA spraying resulted in an increase in the number of flowers, which can be attributed to the removal of apical dominance and the diversion of additional metabolites to flower-bearing growing branches (Grawal *et al*., 2004). Similar finding were observed by Hibbia *et al*. (2012), Grawal *et al*. (2004) in chrysanthemum, Pathania *et al*. (2000) in carnation.

5.2.3 Effect of BA and pinching on seed parameters

5.2.3.1 Days to seed maturity

Various concentrations BA, pinching level and their interactions resulted significant influence on days to seed maturity in phlox. Minimum days to seed maturity was reported with treatment BA 150 ppm, pinching and interaction of BA 50 ppm × no pinching. This delay in seed ripening induced by pinching and BA may be explained by the fact that during both processes, the physiologically mature portion of the shoot was removed, and the new shoot that emerged from the pinched plants took longer to become physiologically mature. Similarly, because BA promotes vegetative growth rather than flowering, flowering was delayed in plants that had been both pinched and BA sprayed. Similar results are also reported by Abdul Rahman *et al*. (2021) in dahlia.

5.2.3.2 Seed yield/plant and seed yield/m^2

The data pertaining to seed yield/plant and seed yield/m^2 as significantly influenced by treatments of BA, pinching levels and their interaction. Treatment BA 200 ppm, pinching and combination of BA 200 ppm × pinching recorded maximum seed yield/plant. However, Maximum seed yield/m^2 was found with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching. As a result of pinching, the plant's apical dominance decreased, resulting in an increase in the number of branches and laterals. BA increased the growth of more leaves, which increased total leaf area, accumulated more photosynthetic activity and ultimately led to the production of more seeds (Blanchard and Runkle, 2008). The results are in agreement with the findings by Sunitha *et al*. (2007), Bhat and Shephered (2007), Maharnor *et al*. (2011) in marigold, Thakare *et al*. (2020) in chrysanthemum.

5.2.3.3 Test weight

The dry weight of the flower was found statistically significant due to the effects of BA and its interaction with pinching. However, pinching failed to exert significant effect on test weight. Maximum test weight was reported with interaction effect of BA 200 ppm, pinching and BA 200 ppm × pinching. The fact cause of this increase in 1000 seed weight was the application of BA, which brought about metabolic changes that impacted the desired product's quality and quantity (Fazeli and Naderi, 2019).The observed results were in line with Singh *et al*. (2017) in marigold.

Chapter VI

SUMMARY AND CONCLUSION

The research entitled "Effect of BA and pinching on growth, flowering and seed yield on calendula and phlox” at Horticultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during winter season, 2021-2022. The investigation comprised of two different factors *viz*., seven level of BA (0, 50, 100, 150, 200, 250 and 300 ppm) and pinching (pinching and no pinching) on calendula and phlox. The study was conducted using a randomized complete block design with seven treatments and three replications. The results of the empirical investigation are illustrated below.

6.1 Experiment no. 1: Effect of BA and pinching on growth, flowering and seed yield in calendula

1. Maximum plant height (60 and 90 DAT) was recorded with treatment no pinching, BA 150 ppm and their interaction of BA 250 ppm × no pinching.
2. Maximum number of primary branches was recorded with treatment pinching and BA 250ppm. While, maximum primary branches (60 to 90 DAT) was noted with interaction of BA 250 ppm × pinching.
3. Secondary branches per plant was reported maximum with treatment BA 150 ppm and interaction of BA 150 ppm × pinching.
4. At 60 days, treatment BA 150 ppm, pinching and their interaction of pinching and foliar spray of BA 100 ppm recorded maximum plant spread.
5. At 90 days, the maximum plant spread was reported with treatment BA 300, pinching and interaction of BA 200 ppm × pinching.
6. Interaction of BA 200 ppm × pinching was reported maximum stem diameter. While, treatment BA 200 ppm and pinching was found maximum plant spread.

7. Maximum fresh weight of leaves was reported with treatment BA 150 ppm and pinching.
8. Maximum dry weight leaves was observed with control, pinching treatment and combination of control × pinching.
9. The maximum leaf area was noted with treatment BA 150 ppm and pinching whereas, interaction of BA 200 ppm × pinching resulted maximum leaf area.
10. Treatment BA 150 ppm and pinching showed maximum leaf area index. However, maximum leaf area index was observed with interaction of BA 300 ppm × pinching.
11. Maximum number of leaves per plant was noticed with treatment 200 ppm BA and pinching.
12. Maximum number of days bud initiation reported with interaction of BA 250 ppm × pinching whereas, treatment BA 250 ppm and pinching recorded maximum days to bud initiation.
13. Maximum bud diameter was found with treatment BA 150 ppm, pinching and their interaction of BA 150 ppm × pinching.
14. Maximum days to flower initiation was recorded with treatment with BA 150 ppm, pinching and interaction of BA 150 ppm × pinching.
15. Maximum flower diameter was reported with interaction of BA 150 ppm × pinching and treatment BA 150 ppm and pinching also found maximum.
16. Treatment BA 200 ppm, pinching and interaction of BA 200 ppm × no pinching resulted maximum peduncle length.
17. The maximum day to flower withering was obtained with treatment BA 50 ppm, pinching and interaction of BA 50 ppm × pinching.
18. Maximum number of flower per plants was observed with treatment BA 200 ppm with pinching and their combination of BA 300 ppm × pinching.
19. The interaction of BA 150 ppm × pinching reported maximum fresh weight of flower while, treatment BA 200 ppm and pinching recorded maximum fresh weight of flower.

20. Maximum dry weight of flower was found with treatment BA 200 ppm and pinching. However, interaction of BA with pinching failed to exert significant effect on dry weight of flower.

21. Maximum day to seed maturity was noticed with interaction of BA 250 ppm × pinching. While, treatment BA 200 ppm and pinching found maximum days to seed maturity.

22. Treatment BA 150 ppm, pinching and interaction of BA 200 ppm × pinching recorded maximum seed yield/plant.

23. The interaction of BA 150 ppm × pinching registered maximum seed yield per $meter^2$. However, maximum seed yield/m^2 was observed with treatment BA 150 ppm and pinching.

24. The treatment BA 150 ppm, pinching and their interactions of BA 250 ppm × pinching found maximum test weight of seed.

25. Maximum number of seeds per flower was reported with treatment BA 150 ppm, pinching and interaction of BA 100 ppm × no pinching.

6.2 Experiment no. 2: Effect of BA and pinching on growth, flowering and seed yield in phlox

1. Maximum plant height (60 and 90 DAT) was recorded with treatment no pinching, BA 200 ppm and interaction of BA 200 ppm × no pinching.

2. Maximum number of primary branches per plant at 60 days was observed with treatment BA 200 ppm, pinching and interaction of BA 300 ppm × pinching.

3. Maximum number of primary branches/plant at 90 days was observed with interaction of BA 200 ppm × pinching whereas maximum primary branches/plant was found with treatment BA 200 ppm and pinching.

4. Maximum secondary branches/plant was influenced with treatment BA 200 ppm, pinching and interaction of BA 200 ppm with pinching.

5. Treatment BA 250 ppm and pinching showed maximum plant spread while the interaction of BA and pinching was found non significant for plant spread at 60 DAT.

6. Maximum plant spread at 90 DAT was recorded with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching.
7. Interaction of BA 200 ppm × pinching has been found significant maximum stem diameter. However, treatment BA 200 ppm and pinching also recorded maximum stem diameter.
8. Maximum fresh weight of leaves was noted with treatment BA 200 ppm, pinching and interaction of BA 200 ppm × pinching.
9. Maximum dry weight of leaves was recorded with treatment BA 200 ppm, pinching and their interaction of BA 200 ppm × pinching.
10. Maximum leaf area was found with treatment BA 300 ppm and pinching. Whereas, combination of BA 200 ppm × pinching observed maximum leaf area.
11. Interaction of BA 200 ppm × pinching was seen maximum leaf area index. While, treatment BA 200 ppm and pinching recorded maximum leaf area index.
12. Maximum number of leaves/plant was observed with treatment BA 300 ppm and pinching. While interaction of BA and pinching was found to be non significant for total number of leaves.
13. Maximum days bud initiation observed with interaction of BA 50 ppm × pinching, control and treatment pinching.
14. Maximum bud diameter was noted with treatment BA 150 ppm and interaction BA 150 ppm × pinching.
15. Early flowering was recorded with treatment BA 150 ppm, no pinching and interaction of BA 50 ppm × no pinching while maximum days to flower initiation was observed with combination of control × pinching.
16. Interaction of BA 150 ppm × pinching was reported maximum flower diameter and treatment BA 250 ppm and pinching also recorded flower diameter.

17. Interaction of BA 150 ppm × pinching reported maximum fresh weight of flower. However, maximum fresh weight of flower was observed with treatment BA 150 ppm and pinching.
18. Maximum dry weight was reported with treatment BA 150 ppm and combination of BA 150 ppm × pinching. Whereas, Pinching failed to exert significant effect on dry weight of the flower.
19. Maximum day to flower withering was reported with treatment BA 150 ppm and pinching. While, interaction of BA 150 ppm × pinching recorded maximum days to flower withering.
20. Maximum number of flower per plants was reported with treatment BA 200 ppm, pinching and combination of BA 300 ppm × pinching.
21. Maximum days to seed maturity was reported with control, pinching and interaction of control × pinching. However, earlier seed maturity was reported with BA 50 ppm × no pinching.
22. Treatment BA 200 ppm, pinching and combination of BA 200 ppm × pinching recorded maximum seed yield/plant.
23. Maximum seed yield/m^2 was found with treatment BA 200 ppm, pinching and interaction effect of BA 200 ppm × pinching.
24. Maximum test weight was reported with interaction of BA 200 ppm × pinching. While, maximum test weight was found with BA 200 ppm and pinching.

Conclusion

From the findings summarized above, it was concluded that BA 150 ppm combined with pinching resulted in superior vegetative growth, flowering and seed yield in calendula. Whereas, BA 200 ppm combined with pinching showed increased vegetative growth and BA 150 ppm combined with pinching had significant influence on flowering and seed yield characters in phlox.

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