EFFECT OF DIFFERENT LEVELS OF ZINC AND PINCHING ON GROWTH, FLOWERING, SEED YIELD AND POST-HARVEST CHARACTERS IN MARIGOLD

काशी हिन्दू विश्वविद्यालय

BANARAS HINDU UNIVERSITY

THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR DEGREE OF

Master of Science (Agriculture)
in
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Supervisor
Dr. Anjana Sisodia

Submitted by
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To,
The Registrar (Academic)
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Through: The Head, Department of Horticulture)

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest characters in marigold"** submitted by **Mr. Deepak Omkarnath, I.D.No. 17412HOR003, Enrolment No. 343034** in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Horticulture**, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

This is to certify that the work has been carried out solely by **Mr. Deepak Omkarnath** under my guidance and data forming the basis of this thesis, to the best of my knowledge are genuine and original and no part of the work has been submitted for any other degree or distinction.

Thanking you.

Yours faithfully

Forwarded

(Anjana Sisodia)
Supervisor

BHU
capital of knowledge

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EXTERNAL EXAMINER

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Date:
Place: *Varanasi* ***(Deepak Omkarnath)***

Contents

LIST OF ABBREVIATIONS

%	per cent
/	per
@	at the rate of
°C	degree centigrade
CD	critical difference
cm	centimeter
et al.	et albeit (and others)
etc.	etcetera
Fig.	figure
g	gram
hrs	hours
ha	hectare
i.e.	that is
kg	kilogram
ml	mililitre
N	Nitrogen
ppm	parts per million
no.	number
RBD	Randomized Block Design
RH	relative humidity
DAT	Days after transplanting
viz.	(videlicet) Namely

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Chapter I

INTRODUCTION

Flowers are regarded as symbol of beauty, love and nature's only gift that exists in various colours and shades and is a loveliest object of the earth. Floriculture has been pinpointed as a dawning industry by the government of India and acquiesced it 100% export aligned status. Floriculture is an age-old farming activity in India having immense potential for generating gainful self-employment among small and marginal farmers. Owing to substantial and patterned increase in the demand for the flowers, the floriculture sector in the field of agriculture has become one of the important commercial trades. All over the world, the floriculture sector now-a-days can be characterized as a sector experiencing rapid changes. Due to globalization and its effect on income development in the different regions of the world, there is a growing per capita consumption in most countries. Besides the traditional centres of production (USA, Japan, Italy, The Netherlands and Columbia), new production centres (like India, China, Africa, Vietnam, etc.) seem to move in direction of more intensive floriculture (Singh, 2006).

Floriculture in India is being scrutinized as fast emerging and rapidly expanding industry. For the export angle of view, now day by day becoming commercially important sector. In India major flower growing states are West Bengal, Tamil Nadu, Karnataka, Uttar Pradesh, Kerala, Andhra Pradesh, Maharashtra etc. Commercial floriculture is one of the most profitable agro-industries in the world and has potential to contribute to the national economies by providing millions of dollars (Bulut, 1994).

Different flowers are used to convey the human feelings. Flowers commonly used for such purposes are rose for love, pansy for thoughts, white carnation for women's love, for jealousy/sorrow French marigold, for vulgare minds, African marigold for self esteem narcissus, daffodil for regards, iris for message, amaryllis for pride, snapdragon for presumption, jasmine for amiability, lily for purity, stock for luxury, sweet pea for departure (Arora, 2008).

Marigold has a prominent place in ornamental horticulture, is a free blooming popular ornamental flower crop and it is one of the most important annual flower crops belongs to the family Asteraceae and genus *Tagetes* cultivated commercially in India and world. The name *Tagetes* were given after 'Tages', demigod known for his beauty. After winning Mexico the king curtez got enraptured by the beauty of the flower and carried it to the attar of virgin "Mary" and thus it has been named after virgin Mary and named as Mary's god, now popularly known as marigold (Marshal, 1969).

The marigold has two main popularly grown species *Tagetes erecta* (2n = 24) and *Tagetes patula* (2n = 48), which have their origin in central and south America, especially Mexico (Kaplan, 1960). *Tagetes erecta* is popularly known as "African marigold", which are erect, hardy, annual, tall about 90 cm and branched. Leaf is pinnate, divided and leaflets are lanceolate and serrated. Howevere, *Tagetes patula* is known as "French marigold" are 30-40 cm tall, hardy and bushy plants (Singh and Sisodia, 2017). There are several other important species in marigold viz.,*Tagetes tenuifolia* (striped marigold), *Tagetes lucida* (sweet-scented marigold), *Tagetes minuta* and *Tagetes lacera*. Marigold compared to other flowering annuals is adaptable to wide agro-climatic conditions and has a fairly good keeping quality. The flower crop is propagated by seeds and comes up well in all types of soil having pH 5.5 to 6.5.

In India, the development of floriculture industry has been very slow in the post independence period up to 1980's due to more attention paid to food grains cultivation, but after liberalization in 1990's a very significant increase in floriculture has been observed. In India, the total area under floriculture sector is 309.26 thousand hectares with a production of 2246.40 thousand MT (Anonymous 2017), which is found to increase in 2017-18 with total area of flower 324 thousand hectares and with a production of 2785 thousand MT. (Anonymous 2018). Out of total floriculture area, 2/3rd area is under traditional flower cultivation. The total area under the cultivation of marigold is 66.13 thousand ha, with the total production of 603.18 thousand MT (Anonymous 2017).

Major marigold producing states and districts in India are Madhya Pradesh (Ratlam, Chhindwara, Indore, Dhar, Ujjain, etc.), Karnataka (Chamaraja nagar, Haveri, Mysore, Bellary, Belgaum, etc.), Gujarat (Ahmadabad, Anand, Gandhinagar, Navsari, Vadodara, *etc*.), Andhra Pradesh (Chittoor, Anantapur, Guntur, Kadapa, Kurnool, etc.), Haryana (Gurgaon, Sonipat, Rohtak, Karnal, Rewari, etc.), Uttar Pardesh (Varanasi, Meerut, Agra, Ballia, Gorakhpur, Janpur, Lucknow, etc.), West-bengal (Mednapur, Nadia, Howrah, etc.) (Anonymous. 2017).

Marigolds are also commonly used in various purposes like worshipping, religious and social functions, wedding, interior decoration and self-adornment and Hindu religious ceremonies. An account describes the marigold being used as garlands to decorate village gods during the harvest festival. Apart from its significance in ornamental horticulture it has been valued for other purposes too. The aromatic oil extracted from marigold is called as "Tagetes oil". It is used for the preparation of high-grade perfumes and also as an insect repellent. It is useful for suppressing the population of nematodes in the field. The coloured pigment extracted from its flower is used in poultry feed in order to improve the colour of egg yolk as well as broiler's skin. (Scott *et al.*1968).

Wild marigold (*Tagetes minuta*) is grown for the extraction of superior quality oil having medicinal properties. Lutein is a carotenoid pigment found mainly in marigold flower. After harvesting, flowers are silage, dried and extracted to get lutein. Presently, its use is increasing worldwide because natural lutein is a nutritional supplement which protects skin from sun damage, prevents low-density lipid cholesterol from oxidizing and possesses lower risks of heart diseases. It inhibits cancer formation in various parts of the body such as lung, prostate, ovary and breast. Lutein also prevents clogging of arteries, delays lung ageing, reduce arthritis and protect eyes by decreasing night blindness and increasing vision ability (Singh and Larky, 2006).

In the past, there was no need for micro nutrients because these trace elements were naturally supplied by the soil. But, due to intensive cultivation, increase in salinity and soil pH in most of the soils, these nutrients are present but are not

available to plants (Ahmad *et al*., 2010). Micro nutrients are to be necessarily taken up by the plants through a foliar application from the soil for good growth and yield of crops. Micro nutrients involved in various metabolic processes and the enzymes. Plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield (Zende. 1996).

Nowadays, among the flower growers zinc micronutrient is gradually gaining momentum in because of its beneficial nutritional support and to ensure better harvest and return. Several factors like doses of micro nutrient, method of application and time of application certainly improve the production of flower crops. Zinc is an important micronutrient for plant growth and development. The supply of this nutrient improves the quality flower production, and foliar application of micronutrients directly affects the quality and yield (Medina *et al.* 2007).

Foliar application of micronutrient zinc in optimum concentration increasing plant height, number of flowers, flower diameter and flower yield. Otherwise, increase doses than normal cause stunted growth of the plant. (Naruk *et al*. 2000). It is well known that zinc acts as a co-factor of many enzymes and affects many biological processes such as photosynthetic reactions, nucleic acids metabolism, and protein and carbohydrate biosynthesis, this is because of the fact that zinc in plant play a vital role due to its requirement in the synthesis of tryptophan which is a precursor of indole acetic acid (Shukla *et al*. 2009).

Zinc improves the biological machines and these are consisting of proteins and enzymes. Foliar application on plants functional the leaves and leaves are green factories where as many chemical process of photosynthesis that produce the compounds, are required for plant growth (Romemheld and El-Fouly, 1999). These establishment processes of nutrient application improve nutrient utilization and lower environmental pollution. These nutrients pass to the plant body easily and where it is required (Saqib *et al,* 2006) and also activates the plant defence mechanism (Anuprita *et al*. 2005; Raut *et al.* 2014; Keram *et al*. 2014). Leaching loss of nutrient is major problem which can be interrupted by the foliar method of application and thus blocking the contamination of usable ground water. Foliar application constitutes the

most effective means of micro-nutrient applications when problem of nutrient fixation in the soil exists.

In many commercial flowering crops factors such as variety, planting time, fertilizers, spacing and cultural operations like gap filling, pinching, weeding and irrigation etc are depending and responsible factors for the successful production of flowers. Whereas, pinching is one of the paramount management practice helpful in accomplishing the twin objective of proper spread of plant and increased number of flowering per plant (high production). The phenomenon in which main stem is dominant over lateral stem is known as apical dominance and auxin (IAA) produced in apical buds inhibits the growth of lateral buds; hence increases plant height and less number of branches are found. The development of axillary branches and flower production are influenced by the presence of apical dominance. The plant grows upward to their final height and later on produces terminal flower buds. After the formation of terminal flower bud, axillary branches are developed, which also produce flowers. However, if the apical portion of shoot is removed early, large number of axillary shoots arise resulting in well shaped bushy plant and producing more number of branches and flowers (Sasikumar *et al*. 2015).

Pinching is the removal of shoot tip along with two to three opened leaves. In the case of African marigold, plants initially grow straight upward to its maximum height and later develop primary branches, which also bear flowers. Mains shoot promotes production of large number of primary branches by early removal of terminal portion that results in well spread bushy plant and more number of good quality flowers. Pinching is one method by which a grower can adjust the time of harvesting according to need and occasion and get desired return of the produce (flower). Therefore, to meet out the increasing demand in market and to earn more profit it is very important to increase the yield.

Considering the importance of marigold as commercial flower crop scrutinize present experiment planned to find out the effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest characters in marigold.

The present investigation was planned with the following objectives.

- To find out the response of zinc on growth, flowering, seed yield and post-harvest characters in marigold.
- To find out the effective or standardized dose of 'Zn' on growth, flowering, seed yield and post-harvest characters for production in marigold.
- To study the effect of pinching on growth, flowering, seed yield and post-harvest longevity of marigold.

Chapter II

REVIEW OF LITERATURE

Marigold is one of the most important annual flower crops cultivated commercially as loose flower in India. The present study was carried out to investigate the "Effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest life of African marigold (*Tegates erecta* L.). The essentiality of micro nutrients and their role have been proved long before. However, zinc required in minute amount or quantity but play an important role in plant life. On the other hand pinching also plays an important role in deciding the productivity and altering the duration of flower in marigold.

The literature pertaining to the effect of zinc and pinching on growth, flowering, flower yield and post-harvest life in marigold crop is ambiguous and as such the literature referring to the effect of micro nutrient (zinc) and pinching in marigold and other flower crop have been reviewed as under.

2.1 Effect of different levels of zinc on growth, flowering, seed yield and post-harvest characters in marigold

Kumar and Arora (2000) conducted a field experiment on gladiolus cv. White Prosperity to assess the various striving reverberation of $FeSO_4$, $ZnSO_4$ or $MnSO_4$ applied singly or in various combinations at 3-leaf or 6-leaf stages. The result revealed and conceded that spike length, number of florets, weight of spike and size of florets were significantly increased with the application of 0.2% $FeSO_4$ + 0.2% $ZnSO_4$. The duration of flowering was longest with 0.4% $FeSO_4$ + 0.2% $ZnSO_4$. Corm production/plant was highest with 0.4% $FeSO_4$ + 0.4%, $MnSO_4$ + 0.2% $ZnSO_4$.

Joshi *et al.* (2002) found that the elemental sulphur at 4g/plant recorded the highest value for flower diameter (7.58 cm) and flower yield (11419 kg/ha) in *Rosa damascena* which were significantly at par with those obtained with the $ZnSO_4$.

Yadav *et al.* (2002) reported that the spike length, rachis length and number of florets per spike in tuberose cv. Double were increased by the soil application of zinc at 20 kg/ha.

Mona *et al.* (2002) reported that appreciable effects of Zn and Mn on the growth and yield were recorded with their combined application recorded better results in African marigold (*Tegetes erecta*). The combined effects of compost and Zn + Mn recorded the best result and thus, increasing the profitability of African marigold cultivation in terms of economic values and returns.

Ali (2003) scrutinize the repercussion studied in a greenhouse and revealed the significant increase in fresh and dry mass in the treated plants in vegetative and flowering stages by the application of Zn and B in flower crop of *Calendula officinalis*.

Paradhan *et al.* (2004) scrutinize in his experiment that gladiolus plants treated with zinc found to obtained higher plant development and leaf area.

Sharma *et al.* (2004) reported that in gladiolus cv. Friendship foliar application of zinc sulphate at 0.6% increased plant height.

Dashora and Verma (2004) studied the effects of growth retardants and micro nutrients on the growth and yield of African marigold (*T. erecta* cv. Pusa Basanti Gainda). They concluded that among the treatments, the foliar spray of 1500 ppm B-9 + 0.5% $ZnSO_4$ markedly affected plant height and number of branches. The highest flower yield (348.80 g) was recorded for the same treatment.

Singh and Singh (2004) investigated in an experiment that application of $ZnSO_4$ at the rate of 20 kg per hectare had resulted maximum number of florets per spike with large size of spike in gladiolus cv. Sylvia.

Jauhari *et al.* (2005) in an investigation found that maximum plant height in gladiolus cv. Red Beauty was obtained by the foliar spray of zinc sulphate at 0.2%.

Katiyar *et al.* (2005) conducted an experiment to observe the effect of Zn, Cu and mixture of both as foliar spray (0.2%) applied in gladiolus cv. Lady First, Pink Friendship and White Prosperity and found that mixture of Zn and Cu increased the vegetative growth and enhanced the floral characteristics like length of spike and number of florets per spike.

Jadhav *et al.* (2005) assessed the effect of $MnSO_4$, $FeSO_4$ and $ZnSO_4$ at 15% and their combinations in *G. jamesonii* cv. Gold Disk. Spraying of all 3 micro nutrients resulted in the maximum plant height and number of leaves/plant.

Khan *et al.* (2006) observed that the application of phosphorus, potassium and zinc resulted striving reverberation in better growth, flower quality and bulb production. The effect of combined application of N, P, K and Zn at 75, 50, 50 and 5 kg ha-1, respectively, was found to be the most suitable dose for obtaining better growth, flower quality and bulb production in tulip cv. Apeldoorn.

Jat *et al.* (2007) conducted a trial to study the effect of foliar application of urea and zinc sulphate (0, 0.5, 1.0 and 1.5%) on plant growth, flowering and flower yield parameters in African marigold (*Tagetes erecta* Linn.). Their experiment results chronicled that foliar application of urea @ 1.0% and zinc sulphate @ 0.5% was found to be the most effective to obtain better plant growth, floral characters and flower yield of African marigold.

Balakrishnan *et al*. (2007) described the effect of micro nutrients on flowering, flower yield and xanthophyll content in African marigold (*Tagetes erecta* Linn.). $FeSO_4$ + $ZnSO_4$ (0.5% each) spray gave positive results of vegetative growth of marigold and maximum value of flower characteristics (quality and yield of flower).

Halder *et al.* (2007) in a trial taken up on the performance in gladiolus achieved longest length of spike (76.89 cm), number of florets (12.18/spike), rachis length (41.14 cm), size of the floret (9.71×8.67 cm) and weight of spike (40.83 g) in spray of zinc at the rate of 3 kg/ha. Whereas, application of zinc at the rate of 3.0

kg/hectare results an increase in the number of corms and cormels along with the individual weight of corm and cormels as compared to control treatment in gladiolus.

Aruna *et al.* (2007) observed increase in the growth and other yield attributing characters due to the application of increased levels of nitrogen and foliar spray of micro nutrients. The application of N at 180 kg/ha along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded increased plant height, number of branches, number of leaves, leaf area, number of spikes/plant, number of flowers per spike and flower yield in crossandra (*Crossandra infundibuliformis*).

Ganga *et al.* (2008) reported the effect of micro nutrients *viz*., zinc sulphate, ferrous sulphate and manganese sulphate in chrysanthemum (*Dendranthema grandiflora* Tzvelev). Whereas, $FeS0_4.7H_20$ at 0.2% recorded maximum number of flowers/spray, followed by $ZnS0_4$ at 0.6% or 0.2% and $FeS0_4$ at 0.6%, which was at par with each other.

Khoshgoftar *et al*. (2008) reported the striving influence of iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) on three rose cultivars. The results manifested significant variation among rose cultivars in developing Zn, Fe and Mn deficiency symptoms and response to micronutrient supplies. For the cultivar Modern Girl and Orange Juice, all the micronutrient treatments resulted in higher stem length and thickness as compared to the control. No significant increase in stem length was observed in cultivar Aqua Fresh. All cultivars had the maximum flower vase life in the added Zn treatments. Moreover, the results indicated the importance of Zn in enhancing the quality of the rose flower.

Pratap *et al*. (2008) conducted field experiment on gladiolus cv. Trader Horn. The result of the experiment showed that application of micro nutrients in the form of $FeSO_4$ @ 1% along with $ZnSO_4$ @ of 0.5% delayed the days taken for opening basal floret and the number of floret opening at a time.

Kumar *et al.* (2009) evaluated the striving effect of zinc sulphate ($ZnSO_4$), ferrous sulphate ($FeSO_4.7H_2O$) and manganese sulphate ($MnSO_4$), on the growth and

flowering of chrysanthemum (*Chrysanthemum morifolium*). The duration of flowering was recorded maximum with foliar spray of $FeSO_4$ at 0.2% (62.3 days) which was significantly at par with $ZnSO_4$ or $MnSO_4$ at 0.4% (61.0 and 60.3 days, respectively) and the number of flowers per spray was increased by all the micro nutrients at lower level (0.2%).

Naik *et al*. (2009) observed in an investigation that with application of 300 mg/L $ZnSO_4$ is treated in gladiolus cv. American Beauty recorded highest numbers of cormels (38.17) per plant.

Reddy and Chaturvedi (2009) conducted a trial to find out the consequence of zinc, calcium and boron on growth and flowering in gladiolus cv. Red Majesty. Foliar application of $ZnSO_4$ at 0.5% found to be significant on different parameters like plant height, length of leaves, days to flowering, length of spike, length of rachis, number of florets per spike and floret length.

El-Naggar (2009) investigate the influence of various concentrations (0.0, 0.2, 0.4, 0.6, 0.8 and 1.0%) of foliar fertilizer (Sangral) that contains both macro-elements (20%N, 20% P, 20% K, 0.12% Mg) and micro-elements (70 ppm Fe, 14 ppm Zn, 16 ppm Cu, 42 ppm Mn, 72 ppm B and 24 ppm Mo) on the growth, flowering and chemical analysis of leaves of *Dianthus caryophyllus* cv. Red Sim. Plants which are treated with foliar nutrition showed significant increase in the growth characteristics (stem length, stem diameter, number of leaves/plant, fresh and dry weight of leaves, etc.) as well as stimulated the flowering parameters (number of days from planting to flowering was reduced, increased both number and diameter of flower, fresh and dry weights of flowers per plant) compared to the untreated plants (control). Application of 0.6 % of foliar fertilizer gave the highest values compared to the other treatment in both seasons.

Kakade *et al*. (2009) revealed the repercussion of $ZnSO_4$ 0.5% and $FeSO_4$ 0.4% in China aster. Maximum value of flower (size, number and yield) and vegetative growth parameters (leaf number, stem diameter and plant spread) were obtained as compared to the values control treatment.

Ahmad *et al*. (2010) studied the effect of foliar application of different micro nutrients (B, Zn and Fe; 0.5%, 1.5% and 1% respectively) on plant growth and flowering of three rose (*Rosa hybrida* L.) cultivars *viz.* Kardinal, Amalia and Rosy Cheeks. The result revealed that the plant height, number of leaves per branch, leaf area, number of flowers per plant and maximum length of flower stalk were observed with B + Zn application.

Nasiri *et al*. (2010) reported increase in flower yield by foliar application of Fe and Zn compared with control (untreated) in chamomile. The highest flower yield (1963.0 kg/ha) was obtained for Fe + Zn spray treatment with about 46.4% improvements in comparison with control and hence Fe and Zn together produces significant effect on yield of flower in chamomile.

Rawia *et al*. (2010) conduct a trial where foliar application of zinc sulphate and benzyl adenine on *Polianthes tuberosa* plants was found effective on the flowers and flower yield. All the studied parameters of flowering characteristics, fresh weight of bulblets and bulblets per plant and number of bulblets per plant were significantly increased by foliar spraying of zinc over the control.

Eid *et al*. (2010) in an investigation found increased number of bulblets per plant and fresh weight of bulblets with foliar application of zinc on tuberose plants.

Sirin (2011) found the maximum growth of gerbera cv. Skyline by the treatment of "Colakoglu-2" nutrient solution formulation consisting of nitrogen (N) 150 ppm, phosphorous (P) 31ppm, potassium (K) 234 ppm, magnesium (Mg) 30 ppm, calcium (Ca) 100 ppm, sulphur 15 ppm, iron (Fe) 8 ppm, manganese (Mn) 5 ppm, boron (B) 105 ppm, copper (Cu) 2 ppm, zinc (Zn) 3 ppm, molybdenum (Mo) 0.2 ppm.

Khosa *et al.* (2011) reported significantly maximum plant height, number of branches/plant and number of leaves/plant in gerbera by the application of zinc @ 200 mg per 100 ml.

Katiyar *et al*. (2012) found the striving repercussion in their trial and revealed that foliar spray of zinc at 0.5% to gladiolus cv. Eurovision reported positive influence on vegetative growth.

Singh *et al*. (2012) revealed that the vegetative growth in gladiolus cv. Sapna significantly influenced by dose of foliar spray of zinc, iron and copper (0.5%, 0.25% and 0.25%, respectively). Inquisition proclaimed that all the vegetative parameters increased significantly by Zn and Cu sprays. Combined effect of Zn and Cu increased the height of plant, length of leaves and width of leaves significantly. All floral characters influenced significantly by Zn except days to heading.

Memon (2013) showed that striving repercussion was found by the application of 40 g $ZnSO_4$ + 20 g $FeSO_4$ in combination and resulted significantly better performance on the growth and flower production of gladiolus.

Saeed *et al*. (2013) in an investigation found the effect of graded levels of zinc on gladiolus and reported that zinc at 6 mg/kg produced maximumt length of spike and flower size. Early days to flowering and more numbers of florets per spike were noted with 8 mg/kg of zinc.

Karuppaiah (2014) carried out a field experiment for chrysanthemum crop to study the effect of micro nutrient *viz*., zinc and iron on growth, yield and quality of flower and found treatment combination of 0.5% zinc sulphate + 0.5% ferrous sulphate to be the best in enhancing plant growth, yield and quality attributes followed by 0.5% zinc sulphate + 0.75% ferrous sulphate and 0.5% zinc sulphate + 0.25% ferrous sulphate.

Hembrom and Singh (2015) described the effect of foliar application of micro nutrient *viz*., Zn and Fe on growth, flowering and bulb yield in lilium. The results revealed that foliar application of $ZnSO_4$ at 0.4% significantly enhanced the number of bulblets per plant, number of scales per bulb, diameter of first flower and diameter of bulb.

Gupta and Kumar (2015) observed the striving reverberation of conducted trial and reported that the maximum plant height, plant spread, length of stalk, weight of flower, yield of flower per plant and flower yield per hectare were observed with spray of $ZnSO_4$ (0.4%).

Saini *et al.* (2015) on investigating the effect of micro nutrient (Fe and Zn) in chrysanthemum conceded that highest value of vegetative growth such as plant height, spread, primary and secondary branches, leaf area, number of sucker per plant were observed by the application of 0.8% $FeSO_4$ and 0.5% $ZnSO_4$.

Chopde *et al.* (2015) conceded that foliar application of 0.4% zinc sulphate and 0.4% iron sulphate was found to give significantly maximum vegetative growth in respect of plant height and leaf area, yield in respect of spikes/plant and corms/plant, quality parameters *viz*., length of spike, length of rachis, florets/spike, diameter of spike and diameter of corm and the earliest 50% flowering in gladiolus.

Shah *et al.* (2016) studied the effect of zinc as a foliar spray on growth and flower production of marigold (*Tagetes erecta* L.). The result revealed that most of the traits were significantly affected by zinc. Maximum plant height, stem diameter, number of flower per plant, fresh flower weight, number of branches per plant and number of leaves per branches were recorded at 0.5% Zinc sulphate application.

Patel *et al.* (2017) revealed that foliar application of $FeSO_4$ @ 2.0% + 0.1% C.A and $ZnSO_4$ @ 0.5% + 0.1% $CaCO_3$ chronicled significantly maximum growth parameters in respect of plant, number of leaves per, fresh weight and dry weight of plant, in respect of florets flower quality diameter and vase life of spike and yield in respect of total number of spike per plant, total number of spike per net plot and total number of spike per hectare. However, interaction effect of $ZnSO_4$ and $FeSO_4$ on flower quality parameters of tuberose was found to be significant *viz*., length of flower spike, rachis length, number of florets per spike, *in-situ* longevity of spike.

Fahad *et al.* (2017) reported the effect of micro nutrient (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Trader Horn. After planting

significantly increased plant height, chlorophyll content of leaf, stalk length of flower, fresh weight of flower, spike length, florets per spike, floret's fresh weight and diameter, flower vase-life, flower diameter as well as fresh weight of corms.

Sahu *et al.* (2017) reported that foliar application of $ZnSO_4$ (0.2%) + $MnSO_4$ (0.2%) + $FeSO_4$ (0.1%) produced significantly maximum plant height, plant spread, number of leaves per plant, length of leaf as well as number of suckers per plant whereas width of leaf was significantly increased as a result of foliar application of $ZnSO_4$ (0.4%) + $MnSO_4$ (0.4%) + $FeSO_4$ (0.3).

Renuka Devi *et al.* (2017) conducted a trial on foliar application of $ZnSO_4$ and CuSO4 on growth, flowering and yield of tuberose (*Polianthes tuberosa* L.) cv. Single. Foliar application of $ZnSO_4$ @ 0.5% gave maximum number of leaves/plant, number of tillers/plant, height of plant, number of spike/plant, length of spike, rachis length, number of florets/spike, and number of bulbs/clump, weight of bulbs/clump, diameter of the largest bulb, yield of spike/ha and yield of bulb/ha. Combination of $ZnSO_4$ and $CuSO_4$ recorded maximum value for growth, flowering and yield parameters.

Patokar *et al.* (2017) conducted a trial in which the treatments comprised of different levels of zinc and iron (0% *i.e.* water spray, 0.25%, 0.5% and 0.75% each). Their result of foliar spray revealed that, foliar application of 0.5% zinc recorded significantly maximum vegetative growth in respect of plant height, spread of plant, yield in respect of number of flowers per plant and flower yield/ha, quality in respect of flower diameter, weight of flower and longevity of intact flower and the earliest first flower bud initiation.

2.2 Effect of different levels of pinching on growth, flowering, seed yield and post-harvest characters in marigold

Pathania *et al.* (2000) reported pinching and a half method (with 6 laterals) which staggered the flower production in two flushes (3^{rd} week of May to July end) and yielded 66.66 flower/m^2 of good quality in a cropping season. Further, in Sim carnation double pinching leads to delayed flowering and maximum number of cut blooms/m^2 (177.77).

Vyakarnahal *et al.* (2001) reported that nipping of auxiliary flower buds in sunflower continuously from 40 to 68 days after sowing gave more seed weight (24.72g/plant), seed recovery (83.68 sowing%), 100 seed weight (4.57g) and processed seed yield (1151.90kg/ha) compared to control (9.79g, 74.44%), 3.72 g and 408.40kg/ha, respectively) in sunflower. Whereas, higher germination percentage (94.90%) and seedling vigour (2672) reported due to continuous pinching of auxiliary flower buds from 40 to 68 days after as compared to control (84.30% and 1844, respectively) in sunflower.

Joshi *et al.* (2002) reported increased fresh weight and dry weight of shoot biomass of the pinched plant as compared to non-pinching plants in pinching treatment in African marigold cv. Cracker Jack.

Misra (2002) reported that in comparison to non-pinching plants the pinching in normal plants gave increased fresh weight and dry weights of African marigold cv. Cracker Jack.

Kumar *et al.* (2002) reported that pinching reduced flower weight but increased dry weight and flower number due to increase in branch number in carnation.

Srivastava *et al.* (2002) conducted a trial on African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda to study the effect of pinching at 40 DAT with wider spacing (40×60 cm).The maximum number of days required for initiation of flowering and longest duration of flowering, increase in the number of flowers per plant, number of days to flowering and duration of flowering was reported in plants pinched at 40 DAT.

Sehrawat *et al*. (2003) observed that pinching when conducted at 30 DAP in marigold (*Tagetes erecta* L.) cv. African Giant Double Orange significantly reduced the plant height, increased in the number of branches, number of days to flower bud initiation, number of days to 50% flowering and flowering duration.

Beniwal *et al*. (2003) in an experiment observed that in chrysanthemum at 25 DAT under the spacing of 20×30 cm the phenomenon of pinching produced maximum plant spread and fresh weight of plant. Whereas, Rakesh *et al.* (2003) revealed that pinching at 35 days after transplanting gave more yield (104.38 g) per plant as compared to control (98.88 g/plant) in chrysanthemum.

Khandelwal *et al.* (2003) investigated and recorded that plants pinched at 20 days after planting compared to control, produced more number of flowers per plant and flower yield as found in control treatment.

Singh and Baboo (2003) revealed through their experiment in chrysanthemum that at 30 days after planting pinching produce more number of flowers (53.90) per plant as compared to control (36.80).

Grawal *et al.* (2004) reported that pinched plant takes some more time (138.35 days) to bud break and produce more number of flowers (10.53/plant) than an un-pinched plant (129.74 days and 7.81/plants, respectively) in chrysanthemum.

Tomar *et al.* (2004a) revealed that maximum number of flowers (48.34/plant) and seed yield (17.71g/plant) was found in double pinching, followed by single pinching (32.86 and 11.29g). However, higher seed test weight (2.95g) was found in control than single and double pinching (2.81g and 2.45g) in African marigold cv. Pusa Basanti Gainda (Tomar *et al.* 2004b).

Singhrot *et al.* (2004) in an experiment on cut flower production in chrysanthemum cv. Flirt and Gauri, revealed that the quality and yield of flowers increased significantly over control in plants sprayed with 50 to 200 ppm GA_3. The flower size and flower stalk length were found maximum in unpinched plants sprayed with 200 ppm GA_3, whereas, yield of flowers per plant were found maximum in plants pinched at 35 days after transplanting. Whereas, number of flowers per plant and yield of flowers per plant in both the cultivars were recorded maximum when plants were pinched at 35 days after transplanting as compared to other pinching treatment (no pinching and pinching after 45 days of transplanting). However, the

maximum weight of flower in both the cultivars was recorded in no pinching treatment as compared to other treatments (Singhrot *et al*. 2005).

Chauhan *et al.* (2005) stated that pinching at 30 days after transplanting recorded more number of flowers and flower yield in marigold as compared to control.

Gyandev (2006) reported that in China aster, pinching at 25 days after transplanting showed significant decrease in plant height and increase in number of flower bearing branches and number of flowers per plant.

Sharma *et al* (2006). Concluded that levels of nitrogen, phosphorus and pinching were assessed to be 200 kg N/ha, 100 kg P_2O_5/ha and pinching at 40 day after transplanting (DAT) for maximum growth and flower production under Jabalpur (Madhya Pradesh) conditions.

Sunitha *et al*. (2007) reported that pinching treatment had recorded significantly higher number of primary branches, flowers and seed yield per plant and per hectare in an research experiment in African marigold (*Tagetes erecta* L.) cv. Orange Double.

Rajbeer *et al*. (2009) reported that flower yield was higher in pinched plants than non-pinched plant in marigold.

Maharnor *et al.* (2011) revealed that increased stem diameter, number of primary branches, spread of plant and flower yield of African marigold was observed when pinching was done after 30 days of transplanting.

Dorajeerao and Mokashi (2012) reported the highest yield in terms of number of flowers per plant by pinching done at 20 days after sowing in chrysanthemum.

Kour *et al*. (2012) reported that delayed pinching at 40 days after transplanting increased the size and quality of flowers.

Kumar *et al.* (2012) reported that plant height, plant spread and yield of flower per hectare were low in early pinching than late pinching in marigold.

Mohanty *et al.* (2012) reported that shoot pinching at 30 days after transplanting improved the plant spread, number of leaves, weight of flowers and yield of flowers in marigold cv. Siracole.

Pushkar and Singh (2012) conducted a trial on African marigold and concluded that the pinching significantly increased all the floral characters. The bud initiation and first flower visibility was observed to be delayed with pinching 30 days after transplanting. The maximum duration of flowering was recorded at pinching 30 days after transplanting.

Sharma *et al*. (2012) reported that the highest flower yield of 203.00 q/ha was obtained with a combination of plant spacing at 45×60 cm (S_3) and pinching of terminal shoots on 30^{th} day after transplanting (P_2). This combination (S_3P_2) which was superior to the flower yields obtained under solo applications i.e. either spacing or pinching was accompanied by better plant growth, larger and higher number of flower per plants and therefore, considered optimum for high flower yield.

Garde *et al*. (2013) described in an experiment of chrysanthemum that the plant height, number of stems per plot, number of nodes per stem, number of inflorescence and better quality plants were significantly influenced by pinching.

Suneetha *et al*. (2014) reported that flowering span was observed minimum in double pinching at 30 and 45 days after transplanting. But the yield characters like number of flowers per plant and flower yield were recorded maximum under single pinching at 30 days after transplanting in China aster.

Sailaja and Panchabhai (2014) reported that in China aster, number of primary branches, plant spread, and stem diameter of plant were found maximum in pinching done at 30 days after transplanting.

Gnyandev *et al.* (2014) reported that pinching at 25 DAT with fertilizer application (270:180:100) and foliar spray of MH (500 ppm) followed by CCC (200 ppm) on same day of pinching resulted in marked increase in number of branches, leaves and flowers per plant with higher seed yield and quality.

Badge *et al*. (2015) conducted an experiment on African marigold and concluded that, no pinching treatments recorded significantly early first flower bud initiation (27.99 days) and first harvesting (43.25 days) with maximum longevity of flower on plant (17.51 days), shelf life of flower (6.71 days), fresh weight of flower (7.40 g), diameter of flower (7.92 cm), length of pedicel flower (8.78 cm).

Meena *et al*. (2015) noted that planting time, wider spacing and pinching at 60 DAT had significant effect on number of days to first flowering and number of flowers/plant in African marigold.

Mohanty *et al*. (2015) observed the effect of planting dates and pinching on growth, flowering in African marigold cv. Sirakole with four planting dates and three levels of pinching. Results revealed that shoot pinching at 30 days after planting improved plant spread, number of leaves, as well as weight of flowers per plot and yield of flowers per hectare. Interaction effect of November planting with single pinching was found beneficial in improving flower yield per hectare.

Singh *et al*. (2015) reported significant increase in number of branches/plant and plant height with pinching and application of medium dose of nitrogen (300 kg/ha) in marigold.

Chauhan *et al.* (2016) revealed that pinching significantly influenced several vegetative parameters like plant spread (52.14 cm), number of leaves per plant (363.24) and leaf area per plant (90.45 cm^2). Pinching delayed some floral attributes like first flower bud initiation (69.93 days), first flowering (79.23 days) in African marigold cv. Pusa Basanti Gainda.

Parhi *et al*. (2016) reported the effect of four planting dates and three levels of pinching in African marigold cv. Sirakole. Shoot pinching at 30 days after planting

improved area of leaves, number and weight of flowers per plant yield of flowers per hectare and also number and weight of seeds per plant.

Baskaran and Abirami (2017) found maximum plant spread (47.2 cm), number of branches (13.7), duration of flowering (36.7 days), number of flowers per plant (56.6), size of flower (6.18 cm), weight of single flower (7.08g), flower yield per plant (347.8g) and seed yield per plant (20.23g) in the double pinching treatment. The flower yield was maximum in double pinching with three times more yield than the control.

Nain *et al*. (2017) conducted a trial on African marigold and concluded that African marigold cv. Local Selection plants pinched at 28 DAT with widest spacing (40 × 40 cm) attained maximum fresh weight of plant (390.40 g), number of buds per plant (45.60), number of flowers per plant (57.37), duration of flowering (55.53 days) and flower yield per plant (479.04 g).

Sathappan (2018) reported that pinching hastened the flowering when compared to application of GA_3, NAA, MH and alar. The yield parameters are also significantly influenced due to growth regulator and pinching treatments in African marigold cv. Pusa Basanti Gainda.

Chopde *et al*. (2018) revealed that the branches plant-1, flowers plant-1, flower yield ha-1 and flowering span were noticed significantly maximum with double pinching.

Singh *et al*. (2018) concluded that in marigold significantly higher number of primary branches per plant, leaf biomass, flower yield per plant, seed yield per plant were found under double pinching and spraying of GA_3 at 150 ppm. Whereas maximum fresh weight of leaf, dry weight of leaf, day to bud initiation, duration of flowering, bud length and number of petals per flower in marigold were recorded in no pinching treatment and application of GA_3 at 150 ppm.

Chapter III

MATERIALS AND METHODS

The research entitled "**Effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest characters in marigold**" was carried out in two sets as mentioned below.

3.1 Experiment No. 1: Effect of different levels of zinc on growth, flowering, seed yield and post-harvest characters in marigold. Details of the experiment are given below.

The present investigation was carried out in five varieties of marigold cv. Pusa Arpita, Pusa Deep, Pusa Basanti, Pusa Bahar, Pusa Narangi Gainda in Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P), during the year of 2018-2019. The brief description of techniques used in the selection of the sample, collection of data and analytical tools and techniques are described well under this chapter, which has been given under the following heads as.

3.1.1 Experimental site

A homogenous piece of land was selected from the composite block of Horticulture Research Farm having even topography with adequate irrigation and proper drainage facilities. The soil was sandy loam having good fertility. The site selected for the experiment is located at a distance of about 10 km away from Varanasi Railway Station in the south-east direction. Geographically, the place is situated at about $23^0$18' north latitude, $83^0$03' east longitudes and at the altitude of 76 metres above the mean sea level.

3.1.2 Climate and weather during the crop growth

3.1.2.1 Prevailing climatic condition

The total geographical area of Varanasi is 1550.3 sq./km. Varanasi is stretched between 82° 56'E-83° 03'E longitude and 25° 14'N-25° 23.5'N latitude and at altitude of 76 m above mean sea level (MSL).

The climate of Varanasi is humid subtropical with large variation between summer and winter temperature. Fog is common in winters and summers are accompanied by hot dry winds. The normal period of set of monsoon in this region is the third week of June and it lasts up to end of September. The average annual rainfall is about 1110 mm and annual potential evapotranspiration is about 1552.2 mm.

3.1.2.2 Temperature

The temperature governs the evaporation from the crop and soil of the experimental field. The mean maximum temperature during experimentation was 34.2°C (October to March) and mean minimum temperature was 9.8°C (December).

3.1.2.3 Relative humidity

During the experiment maximum relative humidity was highest in the month of December (94%) while the lowest relative humidity was recorded during the month of March (68%). The 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, U.P. (Table 3.1).

3.1.3 Soil conditions

Soil of Varanasi is in entisols category. Properties of the soil at the trial site were analysed for different physical and chemical properties. 15 cm deep soil sample from the experimental site were taken as sample and following results were obtained and shown in the table below.

3.1.4 Experimental material

The seeds of the cultivar Pusa Arpita, Pusa Deep, Pusa Basanti, Pusa Bahar, Pusa Narangi Gainda were obtained from the nursery of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P.

Table 3.1: Weekly meteorological data during year-2018-2019

Week No.	Month & Date	Rainfall (mm)	Temp. ^{0}C		R.H. (%)		Wind speed (km/hr)	Sunshine (hours)	Evaporation (mm)
			Max.	Min.	Morn.	Even.			
1	Oct 01-07	0.0	34.2	20.8	83	51	0.8	8.6	3.7
2	08-14	0.0	31.0	20.0	89	61	1.0	8.5	2.9
3	15-21	0.0	33.4	16.5	84	40	0.6	6.1	2.8
4	22-28	0.0	31.5	14.4	89	41	0.4	6.9	2.6
5	29-04	0.0	31.1	16.7	91	48	0.8	7.7	2.3
6	Nov 05-11	0.0	28.2	12.2	87	44	2.3	7.6	2.0
7	12-18	0.0	29.0	11.7	89	45	0.9	7.6	1.8
8	19-25	0.0	27.9	10.1	88	44	0.6	7.2	2.0
9	26-02	0.0	26.4	10.1	93	48	1.1	4.3	1.5
10	Dec 03-09	0.0	20.3	16.3	94	78	1.0	0.2	0.8
11	10-16	0.0	20.2	10.0	94	73	0.8	1.2	0.7
12	17-23	0.0	23.3	9.8	89	50	2.4	3.2	1.8
13	24-31	0.0	20.5	10.9	94	69	1.4	0.2	0.9
14	Jan 01-07	4.8	22.7	6.1	92	46	1.9	6.5	1.6
15	8-14	0.0	21.5	6.8	90	50	2.4	6.7	1.4
16	15-21	0.0	22.1	4.7	90	45	1.2	8.5	1.7
17	22-28	13.0	19.8	10.5	85	69	3.1	4.1	4.2
18	29-04	0.0	21.7	6.3	91	57	2.3	7.1	2.2
19	Feb 05-11	7.8	23.0	9.1	90	61	3.1	4.6	2.0
20	12-18	2.0	23.6	9.1	90	56	2.7	6.4	1.8
21	19-25	0.0	27.2	11.6	79	48	2.7	7.4	2.9
22	26-04	1.8	23.7	9.6	84	54	4.1	5.7	2.6
23	Mar 05-11	0.0	27.7	10.2	86	40	4.4	7.6	3.4
24	12-18	0.0	28.7	14.3	79	47	3.4	6.8	3.0
25	19-25	0.0	31.9	13.2	73	31	4.9	9.5	4.9
26	26-01	0.0	34.2	16.5	68	35	4.5	9.0	4.8

Table 3.2: Method used for determination of different physical and chemical property of soil.

Particular	References	Methods Value	Value (%)
A) Physical/Mechanical composition			
Course sand	Bouyaucos, 1962	Bouyaucos Hydrometer	3.37
Fine sand			45.38
Silt			28.30
Clay			18.40
B) Chemical composition			
Total nitrogen	1973 Modified Kjeldal's methods 0.082	Total nitrogen Jackson	1973 Modified Kjeldal's methods 0.082
Total phosphorus	Jackson, 1973	Bicarbonate extractable P and development of a blue colour	0.075
Total potassium	Jackson, 1973	Neutral normal Ammonium Acetate	0.028
Ph		Neutral normal ammonium by Blackman	7.207

3.1.5 Preparation of solutions

Four levels of zinc (in the form of $ZnSO_4$ @ 0.5%, 0.7%, 0.8% and 1.0%) were prepared for spraying. To prepare the solution of zinc sulphate of concentration 1%, 1 g of zinc sulphate was dissolved into 100 ml of distilled water and neutralised by lime water then made volume up to 1000 ml to prepare stock solution of 1.0%.

Similarly for making 0.5%, 0.7% and 0.8% solution of zinc sulphate ($ZnSO_4$) 0.5 g, 0.7 g and 0.8 g zinc sulphate respectively was dissolved in 100 ml of distilled water and neutralised by lime water then made volume to 1000 ml by adding distilled

water, then desired volume 4000 ml made by adding distilled water sufficient to spray in the field.

3.1.6 Details of experiment

Crop African marigold

Variety

1. Pusa Arpita
2. Pusa Deep
3. Pusa Basanti Gainda
4. Pusa Bahar
5. Pusa Narangi Gainda.

Doses of zinc

1. Zc Control (Distilled water)
2. Z_1 ZnSO4 0.5%
3. Z_2 ZnSO4 0.7%
4. Z_3 ZnSO4 0.8%
5. Z_4 ZnSO4 1.0%

Treatments combinations - 25

1. Zinc 0.0 % × Pusa Arpita
2. Zinc 0.0 % × Pusa Deep
3. Zinc 0.0 % × Pusa Basanti Gainda
4. Zinc 0.0 % × Pusa Bahar
5. Zinc 0.0 % × Pusa Narangi Gainda
6. Zinc 0.5 % × Pusa Arpita
7. Zinc 0.5 % × Pusa Deep
8. Zinc 0.5 % × Pusa Basanti Gainda

9. Zinc 0.5 % × Pusa Bahar
10. Zinc 0.5 % × Pusa Narangi Gainda
11. Zinc 0.7 % × Pusa Arpita
12. Zinc 0.7 % × Pusa Deep
13. Zinc 0.7 % × Pusa Basanti Gainda
14. Zinc 0.7 % × Pusa Bahar
15. Zinc 0.7 % × Pusa Narangi Gainda
16. Zinc 0.8 % × Pusa Arpita
17. Zinc 0.8 % × Pusa Deep
18. Zinc 0.8 % × Pusa Basanti Gainda
19. Zinc 0.8 % × Pusa Bahar
20. Zinc 0.8 % × Pusa Narangi Gainda
21. Zinc 1.0 % × Pusa Arpita
22. Zinc 1.0 % × Pusa Deep
23. Zinc 1.0 % × Pusa Basanti Gainda
24. Zinc 1.0 % × Pusa Bahar
25. Zinc 1.0 % × Pusa Narangi Gainda

Treatments	:	5
Number of replications	:	3
Number of plots	:	75
Design of experiment	:	Randomized Block Design
Plot size	:	2.5 × 1.5 m
Planting distance	:	50 × 50 cm

Fig. 3.1: Layout of the experimental field of zinc spray.

IRRIGATION CHANNEL	R_1		R_2	IRRIGATION CHANNEL	R_3
	V_1Z_C		V_1Z_4		V_1Z_2
	V_1Z_1		V_1Z_2		V_1Z_4
	V_1Z_2		V_1Z_C		V_1Z_1
	V_1Z_3		V_1Z_3		V_1Z_3
	V_1Z_4		V_1Z_1		V_1Z_C
	V_2Z_1		V_2Z_4		V_2Z_3
	V_2Z_C		V_2Z_1		V_2Z_2
	V_2Z_4		V_2Z_3		V_2Z_1
	V_2Z_2		V_2Z_C		V_2Z_4
	V_2Z_3		V_2Z_2		V_2Z_C
	V_3Z_1		V_3Z_C		V_3Z_2
	V_3Z_4		V_3Z_1		V_3Z_C
	V_3Z_C		V_3Z_3		V_3Z_1
	V_3Z_3		V_3Z_4		V_3Z_4
	V_3Z_2		V_3Z_2		V_3Z_3
	V_4Z_C		V_4Z_C		V_4Z_4
	V_4Z_1		V_4Z_3		V_4Z_1
	V_4Z_3		V_4Z_1		V_4Z_C
	V_4Z_2		V_4Z_4		V_4Z_2
	V_4Z_4		V_4Z_2		V_4Z_3
	V_5Z_C		V_5Z_2		V_5Z_2
	V_5Z_1		V_5Z_4		V_5Z_C
	V_5Z_2		V_5Z_1		V_5Z_1
	V_5Z_3		V_5Z_C		V_5Z_3
	V_5Z_4		V_5Z_3		V_5Z_4

3.1.7 Cultural operation

3.1.7.1 Preparation of experimental plot

The experimental plot was brought to fine tilth by once ploughing and repeated harrowing up to a depth of 30-35 cm and the field was made weed free. The experimental plots were laid out as per the treatment requirements. The flat beds of the size of 2.5 m × 1.5 m were prepared and levelled well after the incorporation of well rotten farmyard manure (FYM) @ 5 kg per square meter before the transplanting of seedlings and mixed thoroughly in the soil. The experimental land was levelled and laid out as per the plan adopting Randomized Block Design.

3.1.7.2 Basal nutrients dose

Recommend doses of F.Y.M. *i.e.* 20 tonnes/ha, N 90 kg/ha in the form of Urea, P_2O_5 90 kg/ha in the form of SSP and K_2O 75 kg/ha in the form MOP was given as basal dose at the time of field preparation. 45kg of N, 90 kg of P_2O_5 and 75 kg of K_2O applied in the main field at final preparation of the field before transplanting. Remaining 45kg of N is applied after transplanting as top dressing.

3.1.7.3 Transplanting

Healthy, robust, disease free seedlings were transplanted in the field after 30 days and to protect the seedling from scorching sun light irrigation during evening hour was given.

3.1.7.4 Gap fillings of seedlings

Seedlings of marigold after transplanting should be properly take cared provided with optimum irrigation. Due to the tenderness and softness, seedlings are susceptible to damping off and mites. Therefore, in case of mortality gap fillings of seedlings was done after one week of transplanting.

3.1.7.5 Irrigation

First heavy irrigation was given next day after transplanting in the morning hour. To keep the plant free from moisture stress and proper establishment of the plant three irrigations were given to the crop. After 10 days of transplanting field was again flooded with water. After 40 days of transplanting one more light irrigation was given to the crop.

3.1.7.6 Hoeing and weeding

Hoeing is done manually for the aeration of soil. Hand weeding preferably followed by earthing up was done at proper interval of time as per requirement to check the crop weed competition. Immediate irrigation was given to check the moisture stress in the soil for newly transplanted seedlings of marigold crop. Generally 2-3 weeding are required, first weeding and hoeing was done after 20 days of transplanting, second at 40 days after transplanting and third as per the requirement.

3.1.7.7 Plant protection

Protection measures were taken in marigold against termite, because at the nursery stage and during crop growth period infestation by termite was noticed. Spraying of chloropyriphos 35% E.C (chlorocare) in the form of solution was done after one month of transplanting to protect the crop from mites. Spraying of insecticide and fungicide was also done as per requirement to control insects, pest and diseases in marigold crop.

3.1.7.8 Harvesting

The flowers were harvested at weekly intervals when the central whorls of petals were fully open. The harvesting of the flower for the purpose of observations on flower yield and for seed yield was done early in the morning before 8.00 am at fully opened stage. These flowers were harvested from the net plot and used for further observations.

3.1.8 Observations recorded on morphological parameters

Morphological parameters, *viz*. number of primary and secondary branches per plant, plant spread, stem diameter, fresh weight and dry weight of flower, leaf area per plant, plant height were recorded as per the procedure described below.

3.1.8.1 Number of primary branches per plant

The number of branches arising from the main stem were counted and recorded as the primary branches and this was done at 60 days after transplanting.

3.1.8.2 Length of primary branches.

The lengths of primary branches (cm) of each tagged plant were recorded from each replication with the help of measuring scale (ruler).

3.1.8.3 Number of secondary branches per plant

The branches which arise from the primary branches were counted and recorded as the secondary branches. This was done at the final stage of growth.

3.1.8.4 Length of secondary branches.

The branches arises from the primary branches are called secondary branches. The lengths of secondary branches (cm) of each tagged plant were recorded from each replication with the help of measuring scale (ruler).

3.1.8.5 Stem diameter

Stem girth of tagged plants were measured by using vernier calliper and average were recorded as stem diameter and expressed in millimetre (mm).

3.1.8.6 Spread of the plant

The plant spread was recorded as the horizontal distance between one ends of the canopy to the other holding the measuring tape above the canopy. It was recorded in centimetres.

3.1.8.7 Plant height

The plant height of randomly tagged plants were recorded as the vertical distance from the collar region to the apical bud of the plant and average was worked out and expressed in centimetres.

3.1.8.8 Number of leaves per plant

Number of leaves per plant was counted for each treatment and mean was worked out.

3.1.8.9 Leaf length (cm)

Length of leaf was measured for each treatment of each tagged plants and mean was worked out.

3.1.8.10 Leaf width (cm)

Width of leaf was measured for each treatment from the tagged plants and mean was worked out.

3.1.9 Observations recorded on flowering attributes

3.1.9.1 Days taken to bud initiation

The observation was recorded by counting the days from the date of transplanting to the stage at which the first flower bud was formed from the selected tagged plants of each replication in the main field.

3.1.9.2 Bud length

When 50% buds emerged in the field then bud length was taken from the base to the tip of the bud with the help of digital vernier calliper and average is recorded and expressed in millimetre (mm).

3.1.9.3 Bud diameter

It was taken with the help of vernier calliper after the emergence of 50% buds in the field and expressed in millimetre (mm).

3.1.9.4 Days taken to flower initiation

Observation was recorded from the tagged plants by counting the number of days from the date of transplanting to the stage at which the first flower bloomed in each plant.

3.1.9.5 Diameter of flower

Five fully opened flowers from each tagged plants in each replication were selected and their diameters were measured with the help of vernier calliper by measuring north-south and east-west direction and average was calculated and expressed in mm.

3.1.9.6 Peduncle length

The length of the peduncle of the flower was measured from the origin of the stalk from the main stem to the neck of the flower and expressed in centimetre.

3.1.9.7 Number of flowers per plant

The number of flowers harvested from the tagged plants from each treatment was averaged and recorded as the number of flowers per plant.

3.1.9.8 Fresh weight of the flower

Five flowers were randomly selected from each treated plant and weighed on electronic balance. The mean weight of single flower was expressed in gram.

3.1.9.9 Dry weight of the flower

The dry weight of randomly selected flowers from each treatment was estimated after keeping the flowers in incubator at 68°C for 48 hours or until the

petals turned brown from yellow and become brittle and the dry weight of flower expressed in grams.

3.1.9.10 Flower yield per plot

It was calculated by multiplying total number of flowers per plant to the total no. of plants in plot and average fresh weight of flower in each treatment and expressed in gram.

3.1.10 Observations recorded on seed parameters

3.1.10.1 Weight of seeds per flower

Weights of seeds per flower were manually measured from tagged plants in each treatment of each replication and seed weight was recorded with the help of electronic balance and expressed in grams.

3.1.10.2 100-seed weight

One hundred seeds were manually counted from seeds of tagged plants in each treatment and 100-seed weight were recorded with the help of electronic balance and expressed in grams.

3.1.10.3 Number of seeds per flower

When the seeds become completely dry and change its colour to greyish brown the flowers are harvested and then number of seeds were counted for each replication of variety and each treatment.

3.1.10.4 Seed yield per plant

When all the flowers of the treated plants get dried, were picked up. Seeds were taken out, dried and weighed with the help of electronic balance and the average is expressed in grams and seed yield per plot was also calculated in the same way.

3.1.11 Analytical tools and techniques

The data recorded during the course of experiment were subjected to statistical analysis of variance in Randomised Block Design as described by Panse and Sukhatme (1967). The significance of different treatment effect was judged with the help of 'F' (variance ratio) test. The difference between the significant treatment means and their interactions were tested against the critical difference (CD) at 5 %, where 'F' test was statistically significant. The observations obtained from the experimentation were subjected to analyse with the help of appropriate "ANOVA" table by Cocharn and Cox (1963).

Table 3.3: Analysis of variance

Source of Variance	**d.f.**	**SS**	**MS**	**F_{cal}**
Treatment	(t-1)	TrSS	$TrMS = \frac{TrSS}{(t-1)}$	$\frac{TrSS}{EMS}$
Error	(r-1) (t-1)	ESS	$EMS = \frac{ESS}{(r-1)(t-1)}$	
Total	rt-1	TSS		

Where,

r = Number of replications

t = Number of treatments

d.f. = Degree of freedom

RSS = Replication sum of square

TrSS = Treatment sum of square

ESS = Error sum of square

TSS = Total sum of square

RMS = Replication mean sum of square

TrMS = Treatment mean sum of square

EMS = Error mean sum of square

A significant value of 'F' test indicates that the test entries different significantly among themselves which computing C.D.

$$\text{C.V. (\%)} = \frac{\sqrt{\text{EMS}}}{\text{GM}} \times 100$$

3.2 Experiment No. 2: Effect of pinching on growth, flowering, seed yield and post-harvest characters in marigold. Details of experiment are briefed below.

3.2.1 Experimental site

Same as mentioned above.

3.2.2 Climate and weather conditions

Same as mentioned in above experiment.

3.2.3 Soil conditions

Same as mentioned in above experiment.

3.2.4 Weekly meteorological data 2018-2019

Same as mentioned in above experiment.

3.2.5 Physical properties of soil

Same as mentioned above.

3.2.6 Chemical properties of soil

Same as mentioned in above experiment.

3.2.7 Details of experiment

Crop African marigold

Variety

1. Pusa Arpita
2. Pusa Deep
3. Pusa Basanti Gainda
4. Pusa Bahar
5. Pusa Narangi Gainda.

Treatment combination 20

1. No pinching × Pusa Arpita
2. No pinching × Pusa Deep
3. No pinching × Pusa Basanti Gainda
4. No pinching × Pusa Bahar
5. No pinching × Pusa Narangi Gainda
6. Single pinching × Pusa Arpita
7. Single pinching × Pusa Deep
8. Single pinching × Pusa Basanti Gainda
9. Single pinching × Pusa Bahar
10. Single pinching × Pusa Narangi Gainda
11. Double pinching × Pusa Arpita

12. Double pinching × Pusa Deep

13. Double pinching × Pusa Basanti Gainda

14. Double pinching × Pusa Bahar

15. Double pinching × Pusa Narangi Gainda

16. Third pinching × Pusa Arpita

17. Third pinching × Pusa Deep

18. Third pinching × Pusa Basanti Gainda

19. Third pinching × Pusa Bahar

20. Third pinching × Pusa Narangi Gainda

Treatments	:	4
Number of replications	:	3
Number of plots	:	60
Design of experiment	:	Randomized Block Design
Plot size	:	2.5×1.5 m
Planting distance	:	50 × 50 cm

Fig. 3.2: Layout of the experimental field of pinching.

IRRIGATION CHANNEL	R_1		R_2	IRRIGATION CHANNEL	R_3
	V_1P_0		V_1P_1		V_1P_0
	V_1P_1		V_1P_2		V_1P_3
	V_1P_2		V_1P_0		V_1P_1
	V_1P_3		V_1P_3		V_1P_2
	V_2P_0		V_2P_1		V_2P_3
	V_2P_1		V_2P_0		V_2P_2
	V_2P_3		V_2P_2		V_2P_0
	V_2P_2		V_2P_3		V_2P_1
	V_3P_1		V_3P_3		V_3P_2
	V_3P_0		V_3P_1		V_3P_0
	V_3P_3		V_3P_0		V_3P_1
	V_3P_2		V_3P_2		V_3P_3
	V_4P_0		V_4P_3		V_4P_3
	V_4P_1		V_4P_2		V_4P_1
	V_4P_3		V_4P_0		V_4P_2
	V_4P_2		V_4P_1		V_4P_0
	V_5P_1		V_5P_1		V_5P_0
	V_5P_0		V_5P_3		V_5P_2
	V_5P_2		V_5P_2		V_5P_3
	V_5P_3		V_5P_0		V_5P_1

3.2.8 Intercultural operations.

Same as mentioned in above experiment.

3.2.9 Observations recorded

Similar to above experiment.

3.2.10 Analytical tools and techniques

Similar to above experiment.

Chapter IV

EXPERIMENTAL FINDINGS

The present experiments were accomplished to study the effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest characters in marigold (*Tagetes erecta*). The experiments were carried out at Horticultural Research Farm, Department of Horticulture, Institute of Agricultural Sciences, B.H.U, Varanasi. Whereas, the post-harvest observations of the experiment were carried out in the Post-harvest Laboratory of the Department of Horticulture, B.H.U. Varanasi, U.P.

4.1 Effect of different levels of zinc on growth, flowering and seed yield and post-harvest characters in different varieties of marigold (*Tagetes erecta*)

4.1.1 Effect different levels of zinc in different varieties of marigold on growth characters

4.1.1.1 Plant height (cm)

The data regarding plant height presented in the Table.4.1.1.1 and Fig. 4.1.1.1. It is clearly eloquent that effect of zinc doses on different varieties of marigold and their interactions had shown statistically significant effect on plant height. Application of zinc @ 0.5% resulted maximum plant height (43.50 cm) which was statistically at par with 0.8% zinc (42.08 cm) and 0.7% zinc (41.93 cm), while minimum plant height was recorded in control (39.60 cm). Among the different varieties of marigold maximum plant height was recorded in variety Pusa Basanti Gainda (55.20 cm) followed by Pusa Narangi Gainda (54.49 cm) and the minimum plant height was found in Pusa Deep (25.20 cm).

Studies among the interactions revealed that treatment combination of zinc 0.5% × Pusa Basanti Gainda resulted in maximum plant height (70.43 cm) which was found statistically significant over other treatment combinations (Table.4.1.1.1). The minimum plant height was reported in zinc 0.5% × Pusa Deep (24.08cm) which was statistically at par with zinc 0.0% × Pusa Deep (24.53 cm), zinc 0.8% × Pusa Deep

(25.15 cm), zinc 0.7% × Pusa Deep (26.10 cm), zinc 1.0% × Pusa Deep (26.17 cm), zinc 0.7% × Pusa Arpita (27.82 cm) and zinc 0.5% × Pusa Arpita (28.57 cm).

4.1.1.2 Stem diameter (mm)

Findings with reference to the stem diameter are well depicted in Table 4.1.1.2 and Fig. 4.1.1.2. Maximum stem diameter was recorded with treatment 0.5% zinc (11.16 mm) which was found statistically at par with 0.7% zinc (10.96 mm), while minimum stem diameter was recorded in control (9.33 mm) followed by 1.0% zinc (9.80 mm). Different varieties of marigold during the experiment also augmented with stem diameter of plant. Pusa Narangi Gainda resulted in maximum stem diameter (11.28 mm) which was at par with Pusa Bahar (10.73 mm), while minimum stem diameter was observed in Pusa Arpita (9.14 mm) which was statistically lower than the other varieties.

Interaction between various doses of zinc and varieties of marigold also exhibited significant effect on stem diameter. Interaction of 0.5% zinc with Pusa Basanti Gainda resulted maximum stem diameter (13.14 mm) which was found statistically at par with zinc 0.7% × Pusa Narangi Gainda (12.34 mm) and zinc 0.7% × Pusa Basanti Gainda (12.10 mm). However, minimum stem diameter was observed in interaction zinc 0.8% × Pusa Arpita (8.2 mm) followed by zinc 1.0% × Pusa Arpita (8.35 mm), zinc 1.0% × Pusa Basanti Gainda (8.72 mm), zinc 0.0% × Pusa Deep (8.79 mm), zinc 0.0% × Pusa Basanti Gainda (8.93 mm), zinc 0.8% × Pusa Deep (9.31 mm) and zinc 0.5% × Pusa Arpita (9.43 mm).

4.1.1.3 Plant spread (cm)

The investigation of data mentioning to spread of plant have been cited in Table 4.1.1.3 and illustrated in Fig. 4.1.1.3, which revealed that various doses of zinc and different varieties of marigold had shown significant effect on plant spread. Highest value of plant spread was resulted in treatment 0.5% zinc (44.60 cm) followed by 0.8% zinc (40.85 cm) and 1.0% zinc (39.24 cm), while minimum spread of plant was established in 0.7% zinc (38.89 cm) followed by control (39.31 cm).

Among the five varieties of marigold the maximum value of plant spread was observed in Pusa Deep (49.30 cm) followed by Pusa Arpita (43.36 cm) significant to other varieties, while the minimum spread of plant was recorded in Pusa Bahar (28.37 cm) which was significantly less than the other varieties of marigold.

Interaction effect of zinc doses with various varieties in marigold failed to exert any significant effect on spread of plant. However, maximum plant spread was found in the interaction zinc 0.5% × Pusa Deep (56.54 cm) and the minimum plant spread was found in the interaction of zinc 0.0% × Pusa Bahar (27.12 cm).

4.1.1.4 Number of leaves/plant

The data regarding the number of leaves/plant mentioned in the Table 4.1.1.4 and Fig. 4.1.1.4 clearly showed that various doses of zinc, varieties of marigold and their interactions exhibited significant effect on the number of leaves /plant. It is vivid from the data mentioned in the Table 4.1.1.4 that among the different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc the maximum number of leaves per plant were recorded with 0.5% zinc (113.86) followed by 1.0% zinc (111.92), while the minimum number of leaves per plant were recorded in the control (97.89). Different varieties of marigold taken in the experiment also influenced the number of leaves per plant. Maximum number of number of leaves per plant was observed in the variety Pusa Narangi Gainda (188.92) which was found significantly higher than the other varieties of marigold taken in the experiment trial, while the minimum number of leaves per plant was resulted by variety Pusa Arpita (67.11) followed by variety Pusa Bahar (68.66).

From the perusal of the data, it is clearly seen that interaction of zinc doses with different varieties of marigold showed significant effect on the number of leaves per plant. Treatment combination of 1.0% zinc with Pusa Narangi Gainda gave maximum number of leaves per plant (229.87), which was significantly higher than other interaction, while the minimum number of leaves per plant were resulted in the zinc 0.8% × Pusa Bahar (57.93) interaction and was found statistically at par with zinc 1.0% × Pusa Arpita (58.47), zinc 0.7% × Pusa Bahar (59.53), zinc 0.0% × Pusa

Bahar (64.53), zinc 0.8% × Pusa Arpita (65.27), zinc 0.0% × Pusa Arpita (65.33), zinc 0.5% × Pusa Arpita (71.73), zinc 1.0% × Pusa Basanti Gainda (71.80), zinc 0.8% × Pusa Basanti Gainda (72.47), zinc 0.7 % × Pusa Arpita (74.73), zinc 1.0% × Pusa Bahar (75.69), Pusa Basanti Gainda 76.36) and zinc 0.7% × Pusa Basanti Gainda (78.00).

4.1.1.5 Leaf length (cm)

The length of the leaf was significantly influenced by the different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold and the interaction among the different doses of zinc and marigold varieties (Table 4.1.1.5, and fig 4.1.1.5). Treatment application of 0.5% zinc significantly influenced the leaf length and reported maximum leaf length (20.09 cm) which was found statistically at par with 0.7% zinc (19.84 cm) and 0.8% zinc (19.44 cm). However, 1.0% zinc gave the minimum length of the leaf (18.04 cm) followed by control (18.96 cm). Leaf length was also influenced by the different varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Bahar, Pusa Basanti Gainda and, Pusa Narangi Gainda) where, Pusa Deep gave the maximum leaf length (23.71cm), while the minimum length of the leaf was recorded by Pusa Bahar (17.06 cm) which is statistically at par with, Pusa Narangi Gainda (17.53 cm) and Pusa Basanti Gainda (17.85 cm).

Among the interaction of zinc (control, 0.5%, 0.7%, 0.8% and 1.0%) and marigold varieties, combination of 0.7% zinc with Pusa Deep (26.09 cm) significantly gave maximum leaf length followed by 0.8% zinc with Pusa Deep (24.07 cm) while minimum leaf length was recorded in zinc 1.0 % × Pusa Bahar (14.06 cm)

4.1.1.6 Leaf width (cm)

The observation regarding leaf width as influenced by various treatments (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold and the interaction between various doses of zinc and marigold varieties are presented in Table 4.1.1.6 and illustrated in Fig.4.1.1.6. Treatments application of 0.5% zinc shows the maximum leaf width (10.55 cm) which was statistically at par with control (10.35

cm), 0.8% zinc (10.17 cm) and 0.7% zinc (9.94 cm), while the minimum leaf width was recorded in 1.0% zinc (9.68 cm). Among the different varieties of marigold maximum leaf width was found in variety Pusa Deep (12.11 cm) followed by Pusa Arpita (11.21 cm), while minimum width of leaves per plant was recorded in variety Pusa Basanti Gainda (9.05 cm).

Interaction between various varieties of marigold and various doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc were also reinforced width of leaves per plant. Interaction of 0.5% zinc with Pusa Deep gave the maximum leaf width (13.22 cm) which was significantly at par with zinc 1.0% × Pusa Arpita (12.11 cm), zinc 0.0% × Pusa Deep (12.15 cm), zinc 0.8% × Pusa Arpita (12.23 cm) and zinc 0.8% × Pusa Deep (12.30 cm). The minimum leaf width was reported in the interaction zinc 1.0% × Pusa Basanti Gainda (7.46 cm) followed by zinc 0.8% × Pusa Basanti Gainda (7.76 cm), zinc 1.0% × Pusa Bahar (8.43 cm) and zinc 0.7% × Pusa Narangi Gainda (8.59 cm).

4.1.1.7 Number of primary branch

The data regarding number of primary branches per plant are well depicted in Table 4.1.1.7 and illustrated in Fig. 4.1.1.7. The results revealed that the number of primary branches per plant significantly influenced due to different zinc doses, various varieties of marigold and their interactions. Among the different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, significantly higher number of primary branches per plant were recorded under the treatment dose of 0.5% zinc (13.11) which was found significantly higher to other mention zinc doses, while minimum number of primary branches per plant was recorded with control (10.99). The different varieties of marigold taken in the trial also showed the significant effect regarding number of primary branches per plant. The highest number of primary branches per plant was observed in variety Pusa Deep (13.31) followed by Pusa Narangi Gainda (12.20), while the minimum number of primary branches per plant was noted in Pusa Basanti Gainda (10.71) followed by Pusa Arpita (10.76).

It is also evident from the data that interactions between various zinc doses and marigold varieties were found significant for number of primary branches per plant. The interaction of 0.5% zinc with Pusa Narangi Gainda gave highest number of primary branches per plant (15.40) which was statistically at par with zinc 1.0% × Pusa Arpita (13.80) and zinc 0.5% × Pusa Deep (14.53), while among the different interactions minimum number of primary branches per plant was noted in zinc 0.0% × Pusa Arpita (6.67) and was found lowest than other interactions.

4.1.1.8 Length of primary branch (cm)

The observations on length of primary branches as influenced by different doses of zinc and marigold varieties were recorded and the data are well depicted in Table 4.1.1.8 and illustrated in Fig. 4.1.1.8. It is clearly eloquent from the data that the different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Bahar, Pusa Basanti Gainda and, Pusa Narangi Gainda) and their interactions reported significant effect on length of primary branches. Among various doses of zinc the highest value of length of primary branches were observed by the application of 0.5% zinc (29.14 cm) which was significantly higher than other doses of zinc, while the minimum length of primary branches were observed in control (24.60 cm) which was statistically at par with 1.0% zinc (26.20 cm).

In case of interactions, it was observed that maximum length of primary branches were found in the zinc 0.7% × Pusa Basanti Gainda (48.09 cm) which is at par with zinc 0.8% × Pusa Basanti Gainda (45.62 cm), zinc 0.5% × Pusa Basanti Gainda (47.82 cm) and was found to be higher than other interactions. The minimum length of primary branches among the interactions was observed in zinc 0.0% × Pusa Bahar (16.43 cm) which was significantly at par with zinc 0.0% × Pusa Arpita (16.75 cm), zinc 0.8% × Pusa Bahar (16.93 cm), zinc 0.7% × Pusa Bahar (17.86 cm), zinc 0.5% × Pusa Bahar (18.36 cm) and zinc 1.0% × Pusa Bahar (19.95 cm).

4.1.2 Effect of different levels of zinc in different varieties of marigold on flowering characters

4.1.2.1 Bud initiation (days)

The investigation of the data regarding initiation of bud from date of transplanting mentioned in the Table 4.1.2.1 and illustrated in Fig 4.1.2.1 reveals that there is a significant effect observed on initiation of bud due to various treatments (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc and different varieties of marigold and their interactions. Minimum days to bud initiation from the date of transplanting was reported in the 0.5% zinc (97.47 days) treatment which is followed by 0.7% zinc (99.47 days), while maximum days to bud initiation from the date of transplanting was reported in the control (105.80 days). Significant ramification was strived on different varieties of marigold regarding the days to bud initiation, minimum days to bud initiation were noted in variety Pusa Deep (87.87 days) which is significantly minimum days as compared to other varieties (Pusa Arpita, Pusa Basanti Gainda, Pusa Bahar) followed by Pusa Narangi Gainda (86.00 days), while maximum days to bud initiation from the date of transplanting were reported in variety Pusa Arpita (118.33 days).

In case of interaction between various treatments of zinc and different varieties of marigold, minimum days to bud initiation were exhibited by zinc 0.5% × Pusa Deep (83.67 days) which was statistically at par with zinc 0.5% × Pusa Narangi Gainda, zinc 0.7% × Pusa Deep (84.00 days), zinc 0.8% × Pusa Deep (84.67 days), inc 0.8% × Pusa Narangi Gainda, zinc 1.0% × Pusa Deep (86.00 days) and zinc 0.0% × Pusa Narangi Gainda (86.33 days), while maximum days to bud initiation were reported in zinc 0.0% × Pusa Arpita (121.00 days) followed by zinc 0.7% × Pusa Arpita and zinc 1.0% × Pusa Arpita (119.00 days). Which was found significantly higher in comparison with other interactions mentioned in Table 4.1.2.1.

4.1.2.2 Flower initiation (days)

The statistics with regards to flower initiation as observed in various treatments of zinc and different varieties of marigold flower are well mentioned in the

Table 4.1.2.2 and illustrated in Fig 4.1.2.2 reveals that there is a significant effect observed on flower initiation due to various treatments doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc and different varieties of marigold. Minimum days for flower initiation were reported in 0.5% zinc (107.87 days) treatment followed by treatment of 0.7% zinc (109.80 days), while maximum days to flower initiation were reported in the control (115.73 days). Significant effect was strived on different varieties of marigold regarding the days to flower initiation from the date of transplanting. Minimum days of flower initiation were noted in variety Pusa Deep (85.00 days) which were significantly minimum days as compared to other varieties of marigold (Pusa Arpita, Pusa Basanti Gainda, Pusa Bahar) followed by Pusa Narangi Gainda (99.93 days), while maximum days to flower initiation were reported in variety Pusa Arpita (124.53 days) followed by Pusa Basanti Gainda (123.60 days) and Pusa Bahar (123.87 days).

The interaction between various treatments of zinc and different varieties of marigold were failed to exert any significant effect on days of flower initiation and found non-significant. However, minimum days of flower initiation were observed in interaction zinc 0.5% × Pusa Deep (81.00 days) and maximum days to flower initiation were observed in zinc 0.0% × Pusa Bahar (128.33 days).

4.1.2.3 Number of flowers per plant

Various doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinize and found statistically significant for number of flowers per plant. From the data (Table 4.1.2.3 and illustrated Fig. 4.1.2.3.) it is clearly seen that maximum number of flowers were recorded with dose of 0.5% zinc (46.04) followed by 0.8% zinc (36.18) and 0.7% zinc (35.77), while minimum number of flowers were recorded with control (29.77). Among varieties that have been selected for the experiment, Pusa Deep has resulted significantly maximum number of flowers (55.27) than other varieties of marigold (Pusa Arpita, Pusa Basanti Gainda, Pusa Narangi Gainda), while minimum number of flowers were observed in variety Pusa Bahar (26.54) in marigold.

Interaction of zinc with dose 0.5% in variety Pusa Deep culminated maximum number of flowers (72.05) followed by treatment combination of 0.7% zinc × Pusa Deep (57.30) and 0.7% zinc × Pusa Deep (52.75) and found statistically significant over other interactions cited in Table 4.1.2.3. Minimum number of flowers among the interaction were recorded with the treatment combination of control × Pusa Bahar (23.08) followed by treatment combination of 1.0% zinc × Pusa Bahar (24.63), 0.8% zinc × Pusa Bahar (24.96) and 0.7% zinc × Pusa Bahar (25.07).

4.1.2.4 Number of buds per plant

The application of different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc on different varieties of marigold sight compelling effect on number of buds per plant. The data presented in Table 4.1.2.4 and illustrated in Fig 4.1.2.4 affirms that there was a significant difference existing among different marigold varieties on number of buds per plant. Maximum numbers of buds were found with 0.5% zinc application (59.99), while the minimum numbers of buds (42.92) were recorded in control (0.0% zinc). The significant effects were observed in the different varieties of marigold. The maximum number of buds were found in var. Pusa Deep (72.71) which was found significant to other varieties (Pusa Arpita, Pusa Basanti Gainda, Pusa Narangi Gainda) and minimum number of buds were reported by variety Pusa Bahar (37.75) followed by Pusa Basanti Gainda (39.78).

Treatment combinations of various doses of zinc with different varieties in marigold gave compelling and significant effect on number of buds per pant per plant. Maximum number of buds were resulted from the interaction of 0.5% zinc with Pusa Deep (88.78) followed by zinc 1.0% × Pusa Deep (77.98), zinc 0.8% × Pusa Deep (73.67), zinc 0.7% × Pusa Deep (68.25), while minimum number of buds were chronicled by the treatment combination of 1.0% zinc with Pusa Bahar (32.80) which was statistically at par with treatment combination of zinc 0.0% × Pusa Bahar (35.64), zinc 0.7% × Pusa Basanti Gainda (36.06), zinc 0.7% × Pusa Bahar (36.58), zinc 0.8% × Pusa Basanti Gainda (36.84), zinc 0.8% × Pusa Bahar(36.94),and zinc 1.0% × Pusa Basanti Gainda (37.27).

4.1.2.5 Bud length (mm)

It is clearly apparent from the well established data (Table 4.1.2.5 and Fig 4.1.2.5) that the bud size is significantly influenced by various treatment doses of zinc and different verities of marigold and their interactions. Among the various zinc treatments, 0.5% zinc dose (19.02 mm) results the maximum length of bud in marigold, while minimum bud length was reported in 1.0% zinc (16.06 mm) followed by control (16.70 mm). The data reveals that among different varieties of marigold, significantly higher length of bud was observed with variety Pusa Narangi Gainda (19.68 mm) which was statistically at par with Pusa Basanti Gainda (19.50 mm), while the minimum length of bud was reported by the variety Pusa Arpita (14.01 mm) which was followed by Pusa Deep (15.50 mm) and Pusa Bahar (17.60).

The interactions between various doses of zinc and varieties of marigold produce significant effect on length of bud (mm). Maximum length of bud was noted in zinc 0.5% × Pusa Narangi Gainda (21.78 mm) which is found significantly higher in comparison with other interactions (Table 4.1.2.5) followed by zinc 0.8% × Pusa Basanti Gainda (20.19 mm), while minimum length of bud was observed in zinc 1.0% × Pusa Bahar (12.33 mm) followed by zinc 0.7% × Pusa Arpita (12.65 mm), zinc 1.0% × Pusa Arpita (13.01 mm), zinc 0.8% × Pusa Arpita (13.39 mm) and zinc 0.0% × Pusa Deep (13.52 mm).

4.1.2.6 Bud diameter (mm)

The data with regards to the effect on diameter of bud due to various treatments (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold have been presented in Table 4.1.2.6 and depicted in Fig. 4.1.2.6. It is eloquent from the data that the effect of various treatments of zinc on bud diameter was found significant in different varieties of marigold. Maximum bud diameter was reported in 0.5% zinc (13.99 mm) which was statistically at par with 0.8% zinc (13.25 mm) and significant to other doses of zinc treatments, while minimum bud diameter was found in control (11.11 mm) which was significantly lower than other treatment doses of zinc. Different varieties of marigold also exhibit significant effect on the diameter of

bud. Variety Pusa Basanti Gainda (16.53 mm) exhibited maximum diameter of bud followed by Pusa Bahar (14.23 mm), while minimum bud diameter was reported in Pusa Arpita (9.31 mm) which was significantly lowest to other varieties of marigold (Pusa Deep, Pusa Bahar, Pusa Basanti Gainda and Pusa Narangi Gainda).

The effect of interactions between various treatment doses of zinc and varieties of marigold was found failed to exert any significant effect on the diameter of bud. However, maximum bud diameter was reported in zinc 0.8% × Pusa Basanti Gainda (17.93 mm) and minimum bud diameter was reported in zinc 0.0% × Pusa Arpita (6.65 mm).

4.1.2.7 Flower diameter (mm)

Significant effect was observed by the different treatment doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold and their interactions (Table 4.1.2.7 and Fig. 4.1.2.7). Among the different treatments of zinc, maximum flower diameter was noted in 0.5% zinc (56.76 mm) followed by 1.0% zinc (54.57 mm) and found higher than other treatments (0.0%, 0.8%, 1.0%). Minimum diameter of flower was reported in variety 0.7% zinc (53.44 mm). It is vivid from the data that different varieties of marigold augment the influence of flower diameter. It is apparent from the data that maximum flower diameter was exhibited by variety Pusa Basanti Gainda (63.56 mm) which was significantly found highest among all the varieties of marigold, while the minimum flower diameter was reported in variety Pusa Arpita (48.64 mm) which was followed by Pusa Deep (49.73 mm).

In case of interactions, maximum flower diameter was observed in 0.5% zinc with Pusa Basanti Gainda (68.03 mm) which was statically at par with interaction zinc 0.8% × Pusa Basanti Gainda (66.45 mm) and zinc 0.0% × Pusa Basanti Gainda (65.37 mm). However, minimum flower diameter was exhibited from interaction of 0.0% zinc with Pusa Arpita (43.02 mm) which was statistically at par with zinc 0.8% × Pusa Deep (47.25 mm), zinc 0.0% × Pusa Bahar (48.22 mm), zinc 0.7% × Pusa Arpita (48.83 mm), zinc 1.0% × Pusa Deep (48.91 mm), zinc 1.0% × Pusa Arpita (48.95 mm), zinc 0.8% × Pusa Bahar (48.96 mm) and zinc 0.8% × Pusa Arpita (48.98 mm).

4.1.2.8 Peduncle length (cm)

The data regarding length of peduncle cited in Table 4.1.2.8 and illustrated in Fig. 4.1.2.8 further revealed that the length of peduncle was significantly influenced by different doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc applied, varieties of marigold and interaction of zinc with different varieties of marigold. Among the different doses of zinc, maximum length of peduncle was reported by 0.5% zinc treatment (7.85 cm) which was statistically at par with 0.7% zinc (7.47 cm) and the minimum peduncle length was observed in 1.0% zinc (7.01 cm). In case of different varieties of marigold maximum peduncle length was recorded in Pusa Basanti Gainda (9.39 cm) significantly higher than the other varieties of marigold. Minimum peduncle length was observed in Pusa Arpita (6.51 cm) which was statistically at par with Pusa Deep (6.87 cm) followed by Pusa Basanti Gainda (7.09 cm), Pusa Bahar (7.31 cm).

The interaction of various doses of zinc and varieties of marigold gave significant effect on the length of peduncle. Maximum length of peduncle was resulted in control (0.0% zinc) with Pusa Basanti Gainda (10.43 cm) followed by zinc 1.0% × Pusa Basanti Gainda (9.60 cm), zinc 0.5% × Pusa Basanti Gainda (9.56 cm), while the minimum length of peduncle was recorded in 1.0% zinc with Pusa Arpita (5.41 cm) and which was statistically at par with zinc 1.0% × Pusa Deep (5.93 cm), and zinc 0.0% × Pusa Arpita (6.09 cm) followed by zinc 0.0% × Pusa Deep (6.60 cm), zinc 1.0% × Pusa Narangi Gainda (6.69 cm), zinc 0.8% × Pusa Narangi Gainda (6.79 cm), zinc 0.7% × Pusa Arpita and Zinc 0.7% × Pusa Narangi Gainda (6.87 cm), zinc 0.0% × Pusa Bahar (6.89 cm), zinc 0.8% × Pusa Bahar (6.90 cm) and zinc 0.8% × Pusa Arpita (6.99 cm).

4.1.2.9 Fresh weight of individual flower (g)

Fresh weight of individual flower was significantly influenced by various treatments of zinc, different varieties of marigold and their interactions which can be observed well from the data (Table 4.1.2.9 and Fig. 4.1.2.9). Maximum fresh weight of flower was reported in the treatment application of 0.5% zinc (6.03 g) which was found to be highest among other treatments of zinc (control, 0.7%, 0.8% and 1.0),

while minimum fresh weight of flower was observed in control (4.67 g). Different varieties of marigold exerted significant influence on fresh weight of flower. Maximum fresh weight of flower among the different varieties of marigold was observed in Pusa Basanti Gainda (5.95 g) which is significantly at par with Pusa Bahar (5.85 g) followed by Pusa Narangi Gainda (5.49 g), while minimum fresh weight of flower was reported in Pusa Deep (3.82 g) followed by Pusa Arpita (3.95 g).

From the data (Table 4.1.2.9), it was eloquent that interaction between different treatments of zinc and varieties of marigold also gave the significant effect on the fresh weight of flower. Maximum fresh weight of flower was observed in the interaction 0.5% zinc with Pusa Basanti Gainda (7.68 g) which was statistically significant and highest among all other interactions presented in the data, while minimum fresh weight of flower was observed in zinc 1.0% × Pusa Deep (3.37 g) followed by zinc 0.7% × Pusa Arpita and zinc 0.8% × Pusa Arpita (3.66 g).

4.1.2.10 Dry weight of individual flower (g)

The data mentioned in the Table 4.1.2.10 and Fig.4.1.2.10, affirms that significant effect regarding dry weight of flower was exerted by the different doses of zinc, varieties of marigold and their interactions. Among the different doses of zinc (control, 0.5%, 0.7%, 0.8% and 1.0%) maximum dry weight of flower was observed in treatment 0.5% zinc (0.74 g) which was found significantly higher than other treatments of zinc (control, 0.7%, 0.8% and 1.0%), while minimum dry weight of flower was observed in control (0.59 g). The data showed that significant effect was exerted by the different varieties of marigold regarding dry weight of flower, maximum dry weight of flower was observed in variety Pusa Basanti Gainda (0.87 g) followed by Pusa Bahar (0.80 g) which was significantly higher than other varieties of marigold (Pusa Arpita Pusa Deep, Pusa Bahar, Pusa Narangi Gainda), while minimum dry weight of flower was observed in variety Puas Arpita (0.46 g) which was found to be lowest among the varieties of marigold.

It is eloquent from the data that interactions between various zinc treatments and different varieties of marigold exhibit significant effect on the dry weight of

flower. Maximum dry weight of flower was reported in the interaction zinc 0.5% × Pusa Basanti Gainda (1.08 g) which was highest among all the interactions and statistically significant to other interactions and minimum dry weight of flower was reported in zinc 0.0% × Pusa Arpita (0.40 g) followed by zinc 0.5% × Pusa Arpita, zinc 0.7% × Pusa Arpita (0.43 g), zinc 1.0% × Pusa Deep (0.45 g) and zinc 1.0% × Pusa Arpita (0.49 g).

4.1.2.11 Yield of flowers per plot (Kg)

The statistics with regard to yield of flowers per plot is mentioned in the Table 4.1.2.11 and Fig. 4.1.2.11 reveals that there was a significant effect observed on flower yield per plot due to various treatments (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc and varieties of marigold. Maximum yield of flowers were reported in 0.5% zinc (1.62 Kg) which was statistically at par with 0.8% zinc (1.48 Kg), while minimum yield of flower was observed in control (1.28 Kg). In case of varieties of marigold, the maximum yield of flowers per plot was clearly observed in Pusa Deep (1.75 Kg) which was statistically at par with Pusa Narangi Gainda (1.60 Kg) and found significant than other varieties (Pusa Basanti Gainda, Pusa Bahar), while minimum yield of flowers was observed in Pusa Arpita (0.93 Kg) which was found to be significantly lowest among all the varieties of marigold (Pusa Deep, Pusa Basanti Gainda, Pusa Bahar,Pusa Narangi).

It is vivid from the data regarding flower yield that interactions between various treatment of zinc and varieties of marigold failed to exhibit any significant effect on yield of flowers per plot. However, maximum flowers yield was observed in the interaction of 0.5% zinc with Pusa Deep (1.90 Kg), while minimum yield of flowers was observed in zinc 0.0% × Pusa Deep (0.72 Kg).

4.1.3 Effect of different levels of zinc on different varieties of marigold for seed characters.

4.1.3.1 Number of seeds per flower

It is well perceived from the data (Table 4.1.3.1 and fig. 4.1.3.1), that various doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc on different varieties of marigold

(*Tagetes erecta*) have been scrutinize and found statistically significant on number of seeds per flower. It was found that maximum number of seeds per flower was recorded with dose of 0.5% zinc (243.60) followed by 0.8% zinc (206.46) and 1.0% zinc (205.58), while minimum number of seeds per flower was recorded with control (194.80). Among varieties, Pusa Basanti Gainda (256.53) resulted in significantly maximum number of seeds per flower than other varieties of marigold, while minimum number of seeds per flower was observed in variety Pusa Deep (118.09) of marigold.

Treatment combinations of various doses of zinc with different varieties in marigold i.e. interaction of different doses of zinc with different varieties of marigold were failed to strive any significant effect on the number of seeds per flower. However, maximum number of seeds per flower were reported in interaction zinc 0.5% × Pusa Basanti Gainda (318.92) and the minimum number of seeds per flower was reported in zinc 0.7% × Pusa Deep (110.77).

4.1.3.2 Weight of seeds per flower (g)

From the data concerning the weight of seeds per flower (4.1.3.2 and Fig. 4.1.3.2) significant effect was exhibited by various treatment doses of zinc and different varieties of marigold. In various treatments of zinc maximum seeds weight per flower was reported in 0.5 % zinc (0.43 g) which was statistically at par with 0.8% zinc (0.38 g), while minimum weight of seeds per flower was reported in control (0.35 g) followed by zinc @ 0.7% and zinc @ 1.0 % (0.37 g).

The interaction between various treatments of zinc and varieties of marigold were failed to exert any significant effect on weight of seeds per flower. However, maximum seed weight per flower was reported in the interaction zinc 0.5% × Pusa Bahar (0.57 g) and the minimum weight of seed per flower was reported in zinc 1.0% × Pusa Arpita (0.20 g) followed by zinc 0.7% × Pusa Arpita (0.21 g) and zinc 0.8% × Pusa Arpita (0.22 g).

4.1.3.3 Weight of 100 seeds (g)

It was evident from the data (Table 4.1.3.3 and Fig. 4.1.3.3) that the significant effect was exerted by the various treatments of zinc, varieties of marigold and their interactions. The results regarding weight of 100 seeds as influenced by various treatments of zinc showed that maximum 100 seeds weight was found in the treatment 0.5% zinc (0.26 g) which was significantly higher than other treatments of zinc, while minimum 100 seeds weight was observed in control (0.19 g) followed by 1.0% zinc (0.21 g). The results concern with the 100 seed weight in each variety was found significant. Maximum 100 seed weight was reported in the variety Pusa Deep (0.26 g) which was significantly higher than other varieties mention in the table 4.1.3.3, while minimum 100 seeds weight was reported in variety Pusa Arpita (0.16 g) followed by Pusa Basanti Gainda (0.19 g).

Interactions among the various treatments of zinc and varieties of marigold also exhibit significant effect in concern with 100 seed weight. In various interactions, maximum 100 seeds weight was observed in the zinc 0.5% × Pusa Deep (0.31 g) which is significant to others and statistically at par with zinc 0.5% × Pusa Narangi Gainda (0.29 g), while minimum 100 seeds weight was observed in the interaction zinc 0.0% × Pusa Arpita, zinc 0.7% × Pusa Arpita (0.15 g) followed by zinc 0.0% × Pusa Basanti Gainda, zinc 0.8% × Pusa Arpita and zinc 1.0% × Pusa Arpita (0.16 g).

4.1.3.4 Seed yield per plot

The data with regards to seed yield per plot due to various treatments doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold have been found significant (Table 4.1.3.4 and Fig. 4.1.3.4). Among the application of different doses of zinc, maximum seed yield per plot was reported in treatment of 0.5% zinc (171.71 g) which was highly significant to other doses of zinc treatments (control, 0.7%, 0.8% and 1.0%), while minimum seed yield per plot was found in control (107.42 g) which was significantly lower than other treatment doses of zinc. Different varieties of marigold also exhibit significant effect on the seed yield per plot. Variety Pusa Deep (233.45 g) exhibited maximum seed yield per plot which is highly significant to other

varieties, while minimum seed yield per plot was reported in Pusa Arpita (57.62 g) which was significantly lowest to other varieties of marigold.

The effect of interactions between various treatments of zinc and varieties of marigold was found to exert significant effect on the seed yield per plot. Maximum seed yield per plot was reported in zinc 0.5% × Pusa Deep (326.37 g) highly significant as compared to other interactions and minimum seed yield per plot was reported in zinc 0.8% × Pusa Arpita (43.03 g) which was found to be significantly lowest among all the interactions (Table 4.1.3.4).

4.2 Effect of different levels of pinching on growth, flowering, seed yield and post harvest characters in marigold

4.2.1 Effect of different levels of pinching on vegetative growth in different varieties of marigold.

4.2.1.1 Plant height (cm)

The effect of pinching on different varieties of marigold *(Tagetes erecta)* have been scrutinize and found statistically significant on height of plants (Table 4.2.1.1 and Fig. 4.2.1.1). Maximum plant height (47.77 cm) was recorded with no pinching which was found to be superior among all the pinching treatments while the minimum plant height (38.06 cm) was recorded with third pinching. Height of plant was also influenced by the different varieties of marigold. Among the varieties, Pusa Basanti Gainda recorded maximum plant height (50.30 cm). Pusa Basanti Gainda, Pusa Deep and Pusa Narangi Gainda were found to be statistically at par among themselves with recorded values of 50.30, 39.01 and 48.25 cm respectively, while minimum plant height (33.72 cm) was observed in variety Pusa Bahar. Interaction among the different varieties of marigold with various pinching levels performed were failed to give any significant effect regarding plant height.

Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum plant height (59.80 cm) followed by no pinching (P_0) × Pusa Narangi Gainda (55.03 cm), single pinching (P_1) × Pusa Basanti Gainda (50.92 cm) and single pinching (P_1) × Pusa Narangi Gainda (48.97 cm). Whereas, the minimum height of

plant was observed among the interaction with the treatment combination of third pinching (P_3) × Pusa Bahar (29.39 cm) followed by treatment combination of double pinching (P_2) × Pusa Bahar (31.96 cm) and single pinching × Pusa Bahar (34.15 cm).

4.2.1.2 Stem diameter (mm)

The data concerning with stem diameter (Table 4.2.1.2 and Fig. 4.2.1.2) showed that effect of pinching on different varieties of marigold *(Tagetes erecta)* have been scrutinize and found to be statistically significant on stem diameter. Maximum stem diameter was recorded with double pinching (13.42 mm) followed by third pinching (12.39 mm) and single pinching (11.54 mm) while, the minimum stem diameter (10.87 mm) was recorded with no pinching. Among the varieties, maximum stem diameter was observed in Pusa Basanti Gainda (13.73 mm) which was significantly superior among all the varieties, while minimum stem diameter (11.16 mm) was observed in variety Pusa Bahar.

Interaction of different levels of pinching and varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar and Pusa Narangi Gainda) were found unable to exert any striving significant effect. However, interaction of third pinching (P_2) in variety Pusa Basanti Gainda culminated maximum stem diemeter (15.10 mm) followed by third pinching (P_3) in variety Pusa Basanti Gainda (13.94 mm), double pinching (P_2) × Pusa Deep (13.48 mm), double pinching (P_2) × Pusa Narangi Gainda (13.48 mm) and double pinching (P_2) × Pusa Arpita (13.05 mm). Whereas, the minimum stem diameter was observed among the interaction with the treatment combination of no pinching (P_0) × Pusa Arpita (9.43 mm) followed by treatment combination of no pinching (P_0) × Pusa Deep (9.56 mm) and no pinching × Pusa Bahar (10.68 mm).

4.2.1.3 Plant spread (cm)

Plant spread was significantly influenced by the different levels of pinching in marigold varieties Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar and Pusa Narangi Gainda (Table 4.2.1.3 and Fig. 4.2.1.3). Maximum plant spread (52.79 cm)

was recorded with third pinching (P_3) followed by double pinching (P_2) (48.62 cm), while the minimum plant spread was recorded with no pinching (36.13 cm). Among the varieties, maximum plant spread was observed in Pusa Narangi Gainda (51.43 cm) which was significantly superior among all the varieties, while minimum spread of plant was observed in variety Pusa Bahar (33.94 cm).

Interaction of pinching treatment with different varieties of marigold strived significant effect on plant spread. Interaction of third pinching (P_3) in variety Pusa Narangi Gainda culminated maximum plant spread (60.23 cm) which was statistically at par with third pinching (P_3) × Pusa Arpita (59.14 cm) and third pinching (P_3) × Pusa Basanti Gainda (55.33 cm), whereas the minimum plant spread was observed among the interaction with the treatment combination of no pinching (P_0) × Pusa Bahar (29.77 cm) followed by treatment combination of single pinching (P_1) × Pusa Bahar (34.33 cm), third pinching (P_3) × Pusa Bahar (34.92 cm) and no pinching (P_0) × Pusa Deep (35.23 cm).

4.2.1.4 Number of leaves per plant

The data concerns with (Table 4.2.1.4 and Fig. 4.2.1.4) numbers of leaves per plant reveals that pinching in different varieties of marigold and their interactions were influenced significantly. Maximum number of leaves were recorded in plants with third pinching (266.76) followed by double pinching (249.36), which was found highly significant over all other treatments, while minimum number of leaves per plant were recorded with control (97.43). Among varieties, Pusa Deep resulted significantly maximum number of leaves per plant (317.34) followed by Pusa Narangi Gainda (16.97) and it was found significant over all the varieties, while minimum number of leaves per plant were observed in variety Pusa Bahar (119.48) followed by Pusa Basanti Gainda (165.86) in marigold.

Interaction of third pinching (P_3) in variety Pusa Deep culminated maximum number of leaves per plant (434.29) followed double pinching (P_2) × Pusa Deep, whereas minimum number of leaves per plant among the interactions was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (64.53) followed by

treatment combination of no pinching (P_0) × Pusa Arpita (76.30) and no pinching (P_0) × Pusa Basanti Gainda (76.67).

4.2.1.5 Leaf length (cm)

From the data depicted in Table 4.2.1.5 and Fig. 4.2.1.5 it is clearly shown that the effect of pinching on different varieties of marigold *(Tagetes erecta)* and their interactions have been found statistically significant on leaf length**.** Maximum leaf length was recorded with no pinching (20.59 cm) followed by single pinching (16.14 cm) and double pinching (14.66 cm), while minimum leaf length was recorded with third pinching (13.76 cm). Among varieties, Pusa Deep results significantly maximum leaf length (20.80 cm) and found significantly at par with Pusa Arpita (20.39 cm), while minimum leaf length was observed in variety Pusa Bahar (11.18 cm) followed by Pusa Narangi Gainda (12.28 cm) in marigold.

In case of interactions the data showed that interaction of no pinching (P_0) in variety Pusa Deep has resulted maximum leaf length (24.64 cm), followed by treatment no pinching (P_0) × Pusa Arpita (22.26 cm) and single pinching (P_1) × Pusa Arpita (21.79 cm). Minimum leaf length among the interaction was recorded with the treatment third pinching (P_3) × Pusa Bahar (7.53 cm) followed by double pinching (P_2) × Pusa Bahar (9.07 cm) and third pinching (P_3) × Pusa Narangi Gainda (9.90 cm).

4.2.1.6 Leaf width (cm)

The statistics with regard to leaf width as observed in various treatments are given in Table 4.2.1.6 and Fig. 4.2.1.6 which showed significant effect on leaf width in marigold. Plants of no pinching reported maximum leaf width (10.53 cm), followed by single pinching (9.00 cm) and double pinching (8.27 cm), while minimum leaf width was recorded with third pinching (8.03 cm). Among the marigold varieties, Pusa Deep reported significantly maximum leaf width (10.45 cm) and found at par with Pusa Arpita (10.27 cm), while minimum leaf width was observed in variety Pusa Bahar (6.58 cm) followed by Pusa Narangi Gainda (8.49 cm) in marigold.

Interaction of no pinching (P_0) in variety Pusa Basanti Gainda reported maximum leaf width (11.02 cm) which was found statistically at par with treatment combination of no pinching (P_0) × Pusa Arpita (10.93 cm), single pinching (P_1) × Pusa Arpita (10.87 cm) and single pinching (P_1) × Pusa Deep (10.67 cm). Minimum leaf width among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Bahar (5.13 cm) followed by double pinching (P_2) × Pusa Narangi Gainda (5.27 cm).

4.2.1.7 Number of primary branches

Table 4.2.1.7 and Fig. 4.2.1.7 clarified that significant effects have been reported on plants pinched with different treatments. Maximum numbers of primary branches were recorded with double pinching (19.75), which was found statistically at par with third pinching (19.30) and significant over all other treatments, while minimum numbers of primary branches were recorded with control (8.50). Among varieties, Pusa Deep has resulted significantly maximum number of primary branches (19.90) followed by Pusa Arpita (16.97) and it was found significant over all the varieties, while minimum number of primary branches were observed in variety Pusa Bahar (11.51) followed by Pusa Basanti Gainda (12.30) in marigold.

Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of primary branches (27.87) which was found statistically at par with treatment combination of third pinching (P_3) × Pusa Deep (26.30) and significant over all other interactions. Minimum number of primary branches among the interaction were recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (7.33) followed by treatment combination of single pinching (P_1) × Pusa Bahar (7.77) and no pinching (P_0) × Pusa Basanti Gainda (8.00).

4.2.1.8 Length of primary branch (cm)

Findings with reference to length of primary branches are well mentioned in the Table 4.2.1.8 and Fig. 4.2.1.8. Different levels of pinching, varieties and their interaction found significant on length of primary branches. Maximum length of primary branch was recorded with no pinching (24.49 cm) followed by single

pinching (21.49 cm) and was found significant over all treatments, while minimum length of primary branch was recorded with third pinching (17.42 cm). Among varieties, Pusa Arpita has resulted significantly maximum length of primary branch (22.66 cm) which was found statistically at par with Pusa Deep (21.97 cm) and significant over all other varieties, while minimum length of primary branch was observed in variety Pusa Bahar (16.49 cm) followed by Pusa Narangi Gainda (19.80 cm).

Interaction of no pinching (P_0) in variety Pusa Arpita culminated maximum length of primary branch (28.83 cm) which was followed by combination of no pinching (P_0) × Pusa Basanti Gainda (26.07 cm) and no pinching (P_0) × Pusa Deep (25.84 cm). Minimum length of primary branch among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Bahar (14.37 cm) followed by treatment combination of double pinching (P_2) × Pusa Bahar (15.21 cm).

4.2.1.9 Number of secondary branches

The effect of pinching on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinize and found statistically significant regarding number of secondary branches per plant and well presented in Table 4.2.1.9 and Fig. 4.2.1.9. Maximum number of secondary branches were recorded with third pinching (29.70) followed by double pinching (27.20) which was found significant over all other treatments, while minimum number of secondary branches were recorded with control (5.53). Among different varieties of marigold taken for the experiment, variety Pusa Deep has resulted significantly maximum number of secondary branches (28.78) per plant followed by Pusa Arpita (24.47) and it was found significant over all the varieties of marigold (Pusa Basanti Gainda, Pusa Bahar, Pusa Narangi Gainda), while minimum number of secondary branches were observed in variety Pusa Bahar (11.93) followed by Pusa Basanti Gainda (16.55). Interaction of third pinching (P_3) in variety Pusa Deep culminated maximum number of secondary branches (43.00) which was found highly significant over all other interactions. Minimum number of secondary branches among the interaction were recorded with the treatment combination of no pinching (P_0) × Pusa Basanti Gainda (4.33) followed by treatment combination of single pinching (P_0) × Pusa Arpita (4.67) and no pinching (P_0) × Pusa Deep (6.00).

4.2.1.10 Length of secondary branch (cm)

It is clearly evidenced from Table 4.2.1.10 and Fig. 4.2.1.10 related to length of secondary branch that various treatments have performed significantly. Maximum length of secondary branch was recorded in plants with double pinching (24.49 cm) followed by single pinching (14.33 cm) and was found significant over all treatments, while minimum length of secondary branch was recorded in plants with third pinching (10.65 cm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum length of secondary branch (17.76 cm) followed by Pusa Deep (16.63 cm) and significant over all other varieties, while minimum length of secondary branch was observed in variety Pusa Bahar (8.81cm).

Interaction of plants with double pinching (P_2) in variety Pusa Basanti Gainda culminated maximum length of secondary branch (27.06 cm) which was followed by combination of double pinching (P_2) × Pusa Arpita (25.85 cm), while minimum length of secondary branch among the interaction was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (6.03 cm) followed by treatment combination of third pinching (P_3) × Pusa Bahar (7.07 cm).

4.2.2 Effect of different levels of pinching on flowering characters in different varieties of marigold

4.2.2.1 Number of flowers per plant

Table 4.2.2.1 and Fig. 4.2.2.1 manifested that pinching treatments have influenced the number of flowers per plant significantly. Maximum numbers of flowers per plant were recorded with double pinching (75.70) followed by third pinching (64.50) and significant over all other treatments, while minimum numbers of flowers per plant were recorded with control (35.19). Among varieties, Pusa Deep has resulted significantly maximum number of flowers per plant (163.10) and significant over all other varieties, while minimum number of flowers per plant were observed in variety Pusa Bahar (18.88) in marigold.

Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of flowers per plant (206.95) which was followed by treatment combination of third pinching (P_3) × Pusa Deep (193.20) and single pinching (P_1) × Pusa Deep (177.65). Minimum number of flowers per plant among the interaction were recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (13.00) followed by treatment combination of no pinching (P_0) × Pusa Bahar (18.18) and third pinching (P_3) × Pusa Bahar (18.66).

4.2.2.2 Number of buds per plant

The values concerned with number of buds per plant are presented in Table 4.2.2.2 and Fig. 4.2.2.2 which revealed that various treatments showed significant effects on number of buds per plant. Maximum number of buds per plant was recorded with double pinching (84.53) followed by third pinching (74.31) and significant over all the treatments, while minimum number of buds per plant was recorded with control (45.38). Among varieties, Pusa Deep has resulted significantly maximum number of buds per plant (178.41) and significant over varieties Pusa Arpita, Pusa Basanti Gainda and Pusa Narangi Gainda. While minimum number of buds per plant was observed in variety Pusa Bahar (24.38) in marigold.

Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of buds per plant (219.33) which was statistically at par with treatment combination of third pinching (P_3) × Pusa Deep (205.00) and significant over all other treatments. Minimum number of buds per plant among the interaction was recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (21.66) followed by treatment combination of no pinching (P_0) × Pusa Bahar (22.77) and double pinching (P_2) × Pusa Bahar (24.55).

4.2.2.3 Bud length (mm)

It is apparent from the Table 4.2.2.3 and Fig. 4.2.2.3 that plants with different pinching treatments have found to perform significantly. Maximum bud length was recorded with no pinching (15.50 mm) followed by single pinching (14.93 mm).

While minimum bud length was recorded with third pinching (11.03 mm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum bud length (16.14 mm) followed by Pusa Narangi Gainda (15.36 mm) and significant over all varieties, while minimum bud length was observed in variety Pusa Deep (10.28 mm) followed by Pusa Arpita (11.95 mm).

With reference to bud length interaction of pinching with different varieties of marigold failed to exert any significant effect. However, interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum bud length (18.26 mm) which was followed by combination of no pinching (P_0)× Pusa Narangi Gainda (17.89 mm) and single pinching (P_1) × Pusa Basanti Gainda (17.72 mm). Minimum bud length among the interaction was recorded with the treatment combination of double pinching (P_2) × Pusa Deep (9.51 mm) followed by treatment combination of third pinching (P_3) × Pusa Arpita (9.79 mm).

4.2.2.4 Bud diameter (mm)

The values in Table 4.2.2.4 and Fig. 4.2.2.4 manifested that pinching has influenced the diameter of bud significantly. Maximum bud diameter was recorded with no pinching (11.09 mm) followed by single pinching (10.26 mm), while minimum bud diameter was recorded with third pinching (7.00 mm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum bud diameter (13.44 mm) followed by Pusa Narangi Gainda (10.82 mm) and significant over all varieties, while minimum bud diameter was observed in variety Pusa Arpita (5.36 mm) followed by Pusa Deep (5.63 mm).

Concerning with bud diameter interaction of pinching with various varieties of marigold failed to exert any significant effect. However, interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum bud diameter (15.39 mm) which was followed by combination of single pinching (P_1) × Pusa Basanti Gainda (14.36 mm) and no pinching (P_0)× Pusa Narangi Gainda (13.78 mm). Minimum bud diameter among the interaction was recorded with the treatment combination of third

pinching (P_3) × Pusa Deep (3.62 mm) followed by treatment combination of third pinching (P_3) × Pusa Arpita (3.68 mm).

4.2.2.5 Flower diameter (cm)

It is apparent from the data regarding flower diameter shown by Table 4.2.2.5 and Fig. 4.2.2.5 that various pinching treatments have influenced significant effect on flower diameter. But the interaction of pinching with various varieties of marigold failed to exert any significant effect on bud diameter. Maximum flower diameter was recorded with no pinching (52.89 cm) followed by single pinching (50.92 cm) and was found significant over all treatments, while the minimum flower diameter was recorded with third pinching (46.61 cm). Among varieties of marigold taken for different treatment of pinching, Pusa Basanti Gainda has resulted significantly maximum flower diameter (61.38 cm) followed by Pusa Narangi Gainda (53.60 cm) and significant over varieties Pusa Arpita, Pusa Deep and Pusa Bahar, while minimum flower diameter was observed in variety Pusa Arpita (43.41 cm) followed by Pusa Bahar (43.60 cm).

Interaction regarding flower diameter had not shown significant effect. However, interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum flower diameter (63.44 cm) which was followed by combination of single pinching (P_1) × Pusa Basanti Gainda (62.75 cm) and double pinching (P_2) × Pusa Basanti Gainda (60.82 cm). Minimum flower diameter among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Arpita (39.86 cm) followed by treatment combination of third pinching (P_3) × Pusa Bahar (40.25 cm).

4.2.2.6 Peduncle length (cm)

Results attributed to various pinching treatments on peduncle length are furnished in Table 4.2.2.6 and Fig. 4.2.2.6. Maximum peduncle length was recorded with no pinching (6.02 cm) followed by single pinching (5.71 cm), while minimum peduncle length was recorded with third pinching (3.96 cm). Among varieties, Pusa

Basanti Gainda (7.11 cm) resulted significantly maximum peduncle length followed by Pusa Narangi Gainda (5.14 cm). While minimum peduncle length was observed in variety Pusa Arpita (4.20 cm) followed by Pusa Deep (4.73 cm) and Pusa Bahar (4.77 cm).

Interaction of various levels of pinching with different varieties of marigold concerning peduncle length had shown significant effect. Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum peduncle length (8.40 cm) which statistically at par with single pinching (P_1) × Pusa Basanti Gainda (8.16 cm) followed by double pinching (P_2) × Pusa Basanti Gainda (7.59 cm), while minimum length of peduncle was found in third pinching (P_3) × Pusa Arpita (3.52 cm) which was statistically at par with the interaction third pinching (P_3) × Pusa Deep (3.55 cm) and double pinching (P_2) × Pusa Arpita (3.95 cm), followed by third pinching P_3 × Pusa Bahar (4.19 cm), double pinching (P_2) × Pusa Deep and third pinching P_3 × PusaNarangi Gainda (4.25 cm).

4.2.2.7 Fresh weight of flower (g)

Effects of various pinching treatments on fresh weight of flower have been presented in Table 4.2.2.7 and Fig. 4.2.2.7. Maximum fresh weight of flower was recorded with no pinching (4.68 g) followed by single pinching (4.48 g), while minimum fresh weight of flowers were recorded with third pinching (3.96 g). Among varieties, Pusa Basanti Gainda has resulted significantly maximum fresh weight of flower (5.46 g) and significant over all other varieties, while minimum fresh weight of flower were observed in variety Pusa Arpita (3.49 g) followed by Pusa Deep (3.54 g).

Interaction of pinching with various varieties of marigold failed to exert any significant effect regarding fresh weight of flowers. Though interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum fresh weight of flower (5.91 g) followed by combination of single pinching (P_1) × Pusa Basanti Gainda (5.57 g) and double pinching (P_2) × Pusa Basanti Gainda (5.42 g). Minimum fresh weight of flowers among the interaction was recorded with the treatment combination of third

pinching (P_3) × Pusa Deep (3.28 g) followed by treatment combination of double pinching (P_2) × Pusa Arpita (3.36 g) and double pinching (P_2) × Pusa Deep (3.45 g).

4.2.2.8 Dry weight of flower (g)

Observations related to dry weight of flowers as furnished in Table 4.2.2.8 and Fig. 4.2.2.8 which were found significant. Maximum dry weight of flowers were recorded with no pinching (1.69 g) followed by single pinching (1.59 g), while minimum dry weight of flowers were recorded with third pinching (1.45 g). Among various varieties of marigold selected for pinching experiment, Pusa Basanti Gainda resulted significantly maximum dry weight of flower (2.03 g) followed by Pusa Bahar (1.68 g) and significant over all varieties, while minimum dry weight of flowers were observed in variety Pusa Arpita (1.29 g) followed by Pusa Narangi Gainda (1.33 g).

Interactions of pinching with various varieties of marigold found significant with regards to dry weight of flowers. Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum dry weight of flowers (2.36 g) followed by combination of single pinching (P_1) × Pusa Basanti Gainda (2.20 g) and double pinching (P_2) × Pusa Basanti Gainda (1.80 g). Minimum dry weight of flowers among the interaction were recorded with the treatment combination of double pinching (P_2) × Pusa Arpita (1.23 g) followed by treatment combination of double pinching (P_2) × Pusa Narangi Gainda (1.26 g).

4.2.2.9 Flower yield per plot (g)

It is apparent from the Table 4.2.2.9 and Fig. 4.2.2.9 that the various pinching treatments have shown significant effect. Maximum flower yield per plot was recorded with double pinching (841.97 g) followed by single pinching (702.82 g) and third pinching (685.65 g), while minimum flower yield per plot was recorded with control (565.82 g). Among varieties, Pusa Deep has resulted significantly maximum flower yield per plot (1893.33 g) and significant over all treatments, while minimum flower yield per plot was observed in variety Pusa Bahar (275.39 g) followed by Pusa Basanti Gainda (422.09 g) in marigold.

Interaction of double pinching (P_2) in variety Pusa Deep results maximum flower yield per plot (2136.21 g) which was followed by treatment combination of single pinching (P_1) × Pusa Deep (1955.94 g) and third pinching (P_3) × Pusa Deep (1900.31 g). Minimum flower yield per plot among the interaction was recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (206.89 g) which was followed by no pinching (P_0) × Pusa Bahar (253.41 g) and no pinching (P_0) × Pusa Narangi Gainda (259.22 g).

4.2.3 Effect of different levels of pinching on seed characters in various varieties of marigold

4.2.3.1 Number of seeds per flower

It is well perceived from the data mentioned in Table 4.2.3.1 and Fig 4.2.3.1 that different pinching treatments in different varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, Pusa Narangi Gainda) have shown significant effects on number of seeds per flower. Maximum number of seeds per flower was recorded with no pinching (218.47) followed by single pinching (210.47) and double pinching (206.39), while minimum number of seeds per flower was recorded with third pinching (194.80). Among varieties, Pusa Basanti Gainda resulted significantly maximum number of seeds per flower (269.42) followed by Pusa Narangi Gainda (256.76)and Pusa Bahar (255.52), while minimum number of seeds per flower was observed in variety Pusa Arpita (143.03) in marigold.

Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum number of seeds per flower (286.10) which was statistically at par with treatment combination of no pinching (P_0) × Pusa Bahar (282.63) and no pinching (P_0) × Pusa Narangi Gainda (280.97), single pinching (P_1) × Pusa Basanti Gainda (276.40) and P_1 × Pusa Bahar (275.40). Minimum number of seeds per flower among the interaction was recorded with the treatment combination of second pinching (P_2) × Pusa Deep (108.27) statistically at par with single pinching (P_1) × Pusa Deep (111.17), double pinching (P_2) × Pusa Arpita (115.40), third pinching (P_3) × Pusa Deep (116.11), no pinching (P_0) × Pusa Deep (116.20), single pinching (P_1)× Pusa

Arpita (118.53) followed by treatment combination of no pinching (P_0) × Pusa Arpita (126.43).

4.2.3.2 Weight of 100 seeds (g)

The observation of data concerning with the weight of 100 seeds in different varieties of marigold selected for the experiment are well presented and given in Table 4.2.3.2 and Fig 4.2.3.2 reveals that different levels of pinching treatments have shown significant effect in varieties of marigold. Maximum weight of 100 seeds was recorded with single pinching (0.28 g) followed by double pinching (0.24 g) and third pinching (0.23 g), while minimum weight of 100 seeds was recorded with control (0.19 g). Among varieties, Pusa Deep has resulted significantly maximum weight of 100 seeds (0.27 g) and Pusa Narangi Gainda (0.27 g) followed by Pusa Bahar (0.24 g), while minimum weight of 100 seeds was observed in variety Pusa Arpita (0.17 g) in marigold.

Interaction of single pinching (P_1) in variety Pusa Deep has resulted maximum weight of 100 seeds (0.33 g) which was statistically at par with treatment combination of single pinching (P_1) × Pusa Narangi Gainda (0.31 g) and followed by double pinching (P_2) × Pusa Deep (0.28 g). Minimum weight of 100 seeds among the interaction was recorded with the treatment combination of control (P_0) × Pusa Arpita (0.15 g) which was statistically at par with treatment combination of control (P_0) × Pusa Basanti Gainda (0.16 g), double pinching (P_2) × Pusa Arpita (0.16 g) and third pinching (P_3) × Pusa Arpita (0.16 g).

4.2.3.3 Weight of seeds per flower (g)

The effect different levels of pinching on different varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, Pusa Narangi Gainda) have been scrutinize and found statistically significant in relation to the weight of seeds per flower (Table 4.2.3.3 and Fig 4.2.3.3). Maximum weight of seeds per flower was recorded with no pinching (0.29 g) followed by single pinching (0.26 g) and double pinching (0.23 g), while minimum weight of seeds per flower was recorded with third

pinching (0.21 g). Among varieties, Pusa Deep resulted significantly maximum weight of seeds per flower (0.30 g) followed by Pusa Narangi Gainda (0.26 g) and Pusa Bahar (0.25 g), while minimum weight of seeds per flower was observed in variety Pusa Arpita (0.21 g) in marigold.

However, interaction of pinching with various varieties of marigold failed to exert any significant effect regarding weight of seeds per flower. Interaction of no pinching (P_0) in variety Pusa Deep culminated maximum weight of seeds per flower (0.35 g) followed by single pinching (P_1) × Pusa Deep (0.30 g), no pinching (P_0) × Pusa Bahar (0.29 g) and no pinching (P_0) × Pusa Narangi Gainda (0.29 g). Minimum weight of seeds per flower among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Arpita (0.18 g) and double pinching (P_2) × Pusa Arpita (0.18 g) followed by treatment combination of third pinching (P_3) × Pusa Narangi Gainda (0.20 g).

4.2.3.4 Seed yield per plot (g)

The observation (Table 4.2.3.4 and Fig 4.2.3.4) regarding seed yield per plot clearly showed that different levels of pinching in various varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, Pusa Narangi Gainda) significantly affect the seed yield per plot. Maximum seed yield per plot was recorded with double pinching (57.44 g) followed by single pinching (50.62 g) and third pinching (44.75 g), while minimum seed yield per plot was recorded with control (39.74 g). However, among different varieties of marigold selected for different levels of pinching experiment, Pusa Deep has resulted significantly maximum seed yield per plot (151.53 g) and significant over all treatments. While minimum seed yield per plot was observed in variety Pusa Bahar (13.53 g) followed by Pusa Basanti Gainda (18.92 g) in marigold.

Yield of seed per plot was significantly influenced by the interaction. Interaction of double pinching (P_2) in variety Pusa Deep results maximum seed yield per plot (175.54 g) which was followed by treatment combination of single pinching (P_1) × Pusa Deep (160.69 g) and third pinching (P_3) × Pusa Deep (144.59 g).

Minimum seed yield per plot among the interaction was recorded with the treatment combination of control (P_0) × Pusa Bahar (11.35 g) which was followed by third pinching (P_3) × Pusa Bahar (11.79 g) and single pinching (P_1) × Pusa Bahar (13.50 g).

Table 4.1.1.1: Effect of different level of zinc on plant height (cm) in marigold

Treatments	Plant height (cm)
Control (Zinc 0.0 %)	39.60
Zinc 0.5 %	43.50
Zinc 0.7 %	41.93
Zinc 0.8%	42.08
Zinc 1.0 %	40.43
C.D at 5 %	2.31
Pusa Arpita	32.79
Pusa Deep	25.20
Pusa Basanti Gainda	55.20
Pusa Bahar	39.86
Pusa Narangi Gainda	54.49
C.D at 5 %	2.31
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	32.50
Zinc 0.0 % × Pusa Deep	24.53
Zinc 0.0 % × Pusa Basanti Gainda	47.63
Zinc 0.0 % × Pusa Bahar	38.41
Zinc 0.0 % × Pusa Narangi Gainda	54.93
Zinc 0.5 % × Pusa Arpita	28.57
Zinc 0.5 % × Pusa Deep	24.08
Zinc 0.5 % × Pusa Basanti Gainda	70.43
Zinc 0.5 % × Pusa Bahar	39.37
Zinc 0.5 % × Pusa Narangi Gainda	55.03
Zinc 0.7 % × Pusa Arpita	27.82
Zinc 0.7 % × Pusa Deep	26.10
Zinc 0.7 % × Pusa Basanti Gainda	57.55
Zinc 0.7 % × Pusa Bahar	43.79
Zinc 0.7 % × Pusa Narangi Gainda	54.40
Zinc 0.8 % × Pusa Arpita	38.77
Zinc 0.8 % × Pusa Deep	25.15
Zinc 0.8 % × Pusa Basanti Gainda	52.35
Zinc 0.8 % × Pusa Bahar	38.72
Zinc 0.8 % × Pusa Narangi Gainda	55.44
Zinc 1.0 % × Pusa Arpita	36.28
Zinc 1.0 % × Pusa Deep	26.17
Zinc 1.0 % × Pusa Basanti Gainda	48.05
Zinc 1.0 % × Pusa Bahar	39.00
Zinc 1.0 % × Pusa Narangi Gainda	52.65
C.D at 5 %	5.17

Table 4.1.1.2: Effect of different level of zinc on stem diameter (mm) in marigold

Treatments	Stem diameter (mm) in
Control (Zinc 0.0 %)	9.33
Zinc 0.5 %	11.16
Zinc 0.7 %	10.96
Zinc 0.8%	10.06
Zinc 1.0 %	9.80
C.D at 5 %	0.55
Pusa Arpita	9.14
Pusa Deep	9.48
Pusa Basanti Gainda	10.70
Pusa Bahar	10.73
Pusa Narangi Gainda	11.28
C.D at 5 %	0.55
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	9.05
Zinc 0.0 % × Pusa Deep	8.79
Zinc 0.0 % × Pusa Basanti Gainda	8.93
Zinc 0.0 % × Pusa Bahar	10.09
Zinc 0.0 % × Pusa Narangi Gainda	9.81
Zinc 0.5 % × Pusa Arpita	9.43
Zinc 0.5 % × Pusa Deep	10.02
Zinc 0.5 % × Pusa Basanti Gainda	13.14
Zinc 0.5 % × Pusa Bahar	11.71
Zinc 0.5 % × Pusa Narangi Gainda	11.51
Zinc 0.7 % × Pusa Arpita	10.64
Zinc 0.7 % × Pusa Deep	9.55
Zinc 0.7 % × Pusa Basanti Gainda	12.10
Zinc 0.7 % × Pusa Bahar	10.16
Zinc 0.7 % × Pusa Narangi Gainda	12.34
Zinc 0.8 % × Pusa Arpita	8.22
Zinc 0.8 % × Pusa Deep	9.31
Zinc 0.8 % × Pusa Basanti Gainda	10.59
Zinc 0.8 % × Pusa Bahar	10.33
Zinc 0.8 % × Pusa Narangi Gainda	11.84
Zinc 1.0 % × Pusa Arpita	8.35
Zinc 1.0 % × Pusa Deep	9.73
Zinc 1.0 % × Pusa Basanti Gainda	8.72
Zinc 1.0 % × Pusa Bahar	11.33
Zinc 1.0 % × Pusa Narangi Gainda	10.88
C.D at 5 %	1.24

Table 4.1.1.3: Effect of different level of zinc on plant spread (cm) in marigold

Treatments	Plant spread (cm)
Control (Zinc 0.0 %)	39.31
Zinc 0.5 %	44.60
Zinc 0.7 %	38.89
Zinc 0.8%	40.85
Zinc 1.0 %	39.24
C.D at 5 %	2.63
Pusa Arpita	43.36
Pusa Deep	49.30
Pusa Basanti Gainda	42.35
Pusa Bahar	28.37
Pusa Narangi Gainda	39.50
C.D at 5 %	2.63
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	41.52
Zinc 0.0 % × Pusa Deep	46.39
Zinc 0.0 % × Pusa Basanti Gainda	43.93
Zinc 0.0 % × Pusa Bahar	27.12
Zinc 0.0 % × Pusa Narangi Gainda	37.57
Zinc 0.5 % × Pusa Arpita	47.81
Zinc 0.5 % × Pusa Deep	56.54
Zinc 0.5 % × Pusa Basanti Gainda	45.62
Zinc 0.5 % × Pusa Bahar	30.43
Zinc 0.5 % × Pusa Narangi Gainda	42.59
Zinc 0.7 % × Pusa Arpita	42.57
Zinc 0.7 % × Pusa Deep	46.45
Zinc 0.7 % × Pusa Basanti Gainda	37.92
Zinc 0.7 % × Pusa Bahar	27.90
Zinc 0.7 % × Pusa Narangi Gainda	39.60
Zinc 0.8 % × Pusa Arpita	41.45
Zinc 0.8 % × Pusa Deep	49.55
Zinc 0.8 % × Pusa Basanti Gainda	43.23
Zinc 0.8 % × Pusa Bahar	29.03
Zinc 0.8 % × Pusa Narangi Gainda	40.99
Zinc 1.0 % × Pusa Arpita	43.48
Zinc 1.0 % × Pusa Deep	47.57
Zinc 1.0 % × Pusa Basanti Gainda	41.07
Zinc 1.0 % × Pusa Bahar	27.35
Zinc 1.0 % × Pusa Narangi Gainda	36.73
C.D at 5 %	NS

Table 4.1.1.4: Effect of different level of zinc on number of leaves per plant in marigold

Treatments	No. of leaves per plant
Control (Zinc 0.0 %)	97.89
Zinc 0.5 %	113.86
Zinc 0.7 %	100.79
Zinc 0.8%	99.93
Zinc 1.0 %	111.92
C.D at 5 %	11.02
Pusa Arpita	67.11
Pusa Deep	123.35
Pusa Basanti Gainda	76.36
Pusa Bahar	68.66
Pusa Narangi Gainda	188.92
C.D at 5 %	11.02
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	65.33
Zinc 0.0 % × Pusa Deep	113.93
Zinc 0.0 % × Pusa Basanti Gainda	76.53
Zinc 0.0 % × Pusa Bahar	64.53
Zinc 0.0 % × Pusa Narangi Gainda	169.13
Zinc 0.5 % × Pusa Arpita	71.73
Zinc 0.5 % × Pusa Deep	138.53
Zinc 0.5 % × Pusa Basanti Gainda	83.00
Zinc 0.5 % × Pusa Bahar	85.63
Zinc 0.5 % × Pusa Narangi Gainda	190.40
Zinc 0.7 % × Pusa Arpita	74.73
Zinc 0.7 % × Pusa Deep	124.87
Zinc 0.7 % × Pusa Basanti Gainda	78.00
Zinc 0.7 % × Pusa Bahar	59.53
Zinc 0.7 % × Pusa Narangi Gainda	166.80
Zinc 0.8 % × Pusa Arpita	65.27
Zinc 0.8 % × Pusa Deep	115.60
Zinc 0.8 % × Pusa Basanti Gainda	72.47
Zinc 0.8 % × Pusa Bahar	57.93
Zinc 0.8 % × Pusa Narangi Gainda	188.40
Zinc 1.0 % × Pusa Arpita	58.47
Zinc 1.0 % × Pusa Deep	123.80
Zinc 1.0 % × Pusa Basanti Gainda	71.80
Zinc 1.0 % × Pusa Bahar	75.69
Zinc 1.0 % × Pusa Narangi Gainda	229.87
C.D at 5 %	24.65

Table 4.1.1.5: Effect of different level of zinc on leaf length (cm) in marigold

Treatments	Leaf length (cm)
Control (Zinc 0.0 %)	18.96
Zinc 0.5 %	20.09
Zinc 0.7 %	19.84
Zinc 0.8%	19.44
Zinc 1.0 %	18.04
C.D at 5 %	1.05
Pusa Arpita	20.22
Pusa Deep	23.71
Pusa Basanti Gainda	17.85
Pusa Bahar	17.06
Pusa Narangi Gainda	17.53
C.D at 5 %	1.05
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	21.07
Zinc 0.0 % × Pusa Deep	22.27
Zinc 0.0 % × Pusa Basanti Gainda	17.42
Zinc 0.0 % × Pusa Bahar	17.17
Zinc 0.0 % × Pusa Narangi Gainda	16.87
Zinc 0.5 % × Pusa Arpita	18.65
Zinc 0.5 % × Pusa Deep	24.64
Zinc 0.5 % × Pusa Basanti Gainda	20.62
Zinc 0.5 % × Pusa Bahar	18.90
Zinc 0.5 % × Pusa Narangi Gainda	17.63
Zinc 0.7 % × Pusa Arpita	17.58
Zinc 0.7 % × Pusa Deep	26.09
Zinc 0.7 % × Pusa Basanti Gainda	19.94
Zinc 0.7 % × Pusa Bahar	17.93
Zinc 0.7 % × Pusa Narangi Gainda	17.64
Zinc 0.8 % × Pusa Arpita	21.43
Zinc 0.8 % × Pusa Deep	24.07
Zinc 0.8 % × Pusa Basanti Gainda	15.65
Zinc 0.8 % × Pusa Bahar	17.26
Zinc 0.8 % × Pusa Narangi Gainda	18.80
Zinc 1.0 % × Pusa Arpita	22.36
Zinc 1.0 % × Pusa Deep	21.46
Zinc 1.0 % × Pusa Basanti Gainda	15.61
Zinc 1.0 % × Pusa Bahar	14.07
Zinc 1.0 % × Pusa Narangi Gainda	16.69
C.D at 5 %	2.35

Table 4.1.1.6: Effect of different level of zinc on leaf width (cm) in marigold

Treatments	Leaf width (cm)
Control (Zinc 0.0 %)	10.35
Zinc 0.5 %	10.55
Zinc 0.7 %	9.94
Zinc 0.8%	10.17
Zinc 1.0 %	9.68
C.D at 5 %	0.59
Pusa Arpita	11.21
Pusa Deep	12.11
Pusa Basanti Gainda	9.05
Pusa Bahar	9.27
Pusa Narangi Gainda	9.07
C.D at 5 %	0.59
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	10.03
Zinc 0.0 % × Pusa Deep	12.15
Zinc 0.0 % × Pusa Basanti Gainda	11.02
Zinc 0.0 % × Pusa Bahar	9.66
Zinc 0.0 % × Pusa Narangi Gainda	8.89
Zinc 0.5 % × Pusa Arpita	10.39
Zinc 0.5 % × Pusa Deep	13.22
Zinc 0.5 % × Pusa Basanti Gainda	9.94
Zinc 0.5 % × Pusa Bahar	9.83
Zinc 0.5 % × Pusa Narangi Gainda	9.36
Zinc 0.7 % × Pusa Arpita	11.30
Zinc 0.7 % × Pusa Deep	11.56
Zinc 0.7 % × Pusa Basanti Gainda	9.04
Zinc 0.7 % × Pusa Bahar	9.22
Zinc 0.7 % × Pusa Narangi Gainda	8.59
Zinc 0.8 % × Pusa Arpita	12.23
Zinc 0.8 % × Pusa Deep	12.30
Zinc 0.8 % × Pusa Basanti Gainda	7.76
Zinc 0.8 % × Pusa Bahar	9.18
Zinc 0.8 % × Pusa Narangi Gainda	9.38
Zinc 1.0 % × Pusa Arpita	12.11
Zinc 1.0 % × Pusa Deep	11.30
Zinc 1.0 % × Pusa Basanti Gainda	7.46
Zinc 1.0 % × Pusa Bahar	8.43
Zinc 1.0 % × Pusa Narangi Gainda	9.10
C.D at 5 %	1.92

Table 4.1.1.7: Effect of different level of zinc on number of primary branch in marigold

Treatments	Number of primary branches
Control (Zinc 0.0 %)	10.99
Zinc 0.5 %	13.11
Zinc 0.7 %	11.31
Zinc 0.8%	11.60
Zinc 1.0 %	11.36
C.D at 5 %	0.82
Pusa Arpita	10.76
Pusa Deep	13.31
Pusa Basanti Gainda	10.71
Pusa Bahar	11.39
Pusa Narangi Gainda	12.20
C.D at 5 %	0.82
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	6.67
Zinc 0.0 % × Pusa Deep	13.20
Zinc 0.0 % × Pusa Basanti Gainda	12.47
Zinc 0.0 % × Pusa Bahar	12.40
Zinc 0.0 % × Pusa Narangi Gainda	10.20
Zinc 0.5 % × Pusa Arpita	10.07
Zinc 0.5 % × Pusa Deep	14.53
Zinc 0.5 % × Pusa Basanti Gainda	13.00
Zinc 0.5 % × Pusa Bahar	12.53
Zinc 0.5 % × Pusa Narangi Gainda	15.40
Zinc 0.7 % × Pusa Arpita	9.93
Zinc 0.7 % × Pusa Deep	11.93
Zinc 0.7 % × Pusa Basanti Gainda	10.27
Zinc 0.7 % × Pusa Bahar	11.20
Zinc 0.7 % × Pusa Narangi Gainda	13.20
Zinc 0.8 % × Pusa Arpita	13.33
Zinc 0.8 % × Pusa Deep	13.33
Zinc 0.8 % × Pusa Basanti Gainda	8.87
Zinc 0.8 % × Pusa Bahar	9.33
Zinc 0.8 % × Pusa Narangi Gainda	13.13
Zinc 1.0 % × Pusa Arpita	13.80
Zinc 1.0 % × Pusa Deep	13.53
Zinc 1.0 % × Pusa Basanti Gainda	8.93
Zinc 1.0 % × Pusa Bahar	11.47
Zinc 1.0 % × Pusa Narangi Gainda	9.07
C.D at 5 %	1.83

Table 4.1.1.8: Effect of different level of zinc on length of primary branch (cm) in marigold

Treatments	Length of primary branches (cm)
Control (Zinc 0.0 %)	24.60
Zinc 0.5 %	29.14
Zinc 0.7 %	28.64
Zinc 0.8%	27.47
Zinc 1.0 %	26.20
C.D at 5 %	1.61
Pusa Arpita	23.79
Pusa Deep	22.42
Pusa Basanti Gainda	43.18
Pusa Bahar	17.91
Pusa Narangi Gainda	28.75
C.D at 5 %	1.61
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	16.75
Zinc 0.0 % × Pusa Deep	23.76
Zinc 0.0 % × Pusa Basanti Gainda	36.13
Zinc 0.0 % × Pusa Bahar	16.43
Zinc 0.0 % × Pusa Narangi Gainda	29.92
Zinc 0.5 % × Pusa Arpita	32.07
Zinc 0.5 % × Pusa Deep	22.19
Zinc 0.5 % × Pusa Basanti Gainda	47.82
Zinc 0.5 % × Pusa Bahar	18.36
Zinc 0.5 % × Pusa Narangi Gainda	25.25
Zinc 0.7 % × Pusa Arpita	24.77
Zinc 0.7 % × Pusa Deep	22.75
Zinc 0.7 % × Pusa Basanti Gainda	48.09
Zinc 0.7 % × Pusa Bahar	17.86
Zinc 0.7 % × Pusa Narangi Gainda	29.72
Zinc 0.8 % × Pusa Arpita	21.50
Zinc 0.8 % × Pusa Deep	22.97
Zinc 0.8 % × Pusa Basanti Gainda	45.62
Zinc 0.8 % × Pusa Bahar	16.93
Zinc 0.8 % × Pusa Narangi Gainda	30.32
Zinc 1.0 % × Pusa Arpita	23.84
Zinc 1.0 % × Pusa Deep	20.43
Zinc 1.0 % × Pusa Basanti Gainda	38.23
Zinc 1.0 % × Pusa Bahar	19.95
Zinc 1.0 % × Pusa Narangi Gainda	28.54
C.D at 5 %	3.60

Table 4.1.2.1: Effect of different level of zinc on bud initiation (days) in marigold

Treatments	Bud Initiation (days)
Control (Zinc 0.0 %)	105.80
Zinc 0.5 %	97.47
Zinc 0.7 %	99.47
Zinc 0.8%	99.80
Zinc 1.0 %	101.27
C.D at 5 %	1.62
Pusa Arpita	118.33
Pusa Deep	87.87
Pusa Basanti Gainda	103.00
Pusa Bahar	108.60
Pusa Narangi Gainda	86.00
C.D at 5 %	1.62
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	121.00
Zinc 0.0 % × Pusa Deep	101.00
Zinc 0.0 % × Pusa Basanti Gainda	107.67
Zinc 0.0 % × Pusa Bahar	113.00
Zinc 0.0 % × Pusa Narangi Gainda	86.33
Zinc 0.5 % × Pusa Arpita	114.67
Zinc 0.5 % × Pusa Deep	83.67
Zinc 0.5 % × Pusa Basanti Gainda	99.67
Zinc 0.5 % × Pusa Bahar	105.33
Zinc 0.5 % × Pusa Narangi Gainda	84.00
Zinc 0.7 % × Pusa Arpita	119.00
Zinc 0.7 % × Pusa Deep	84.00
Zinc 0.7 % × Pusa Basanti Gainda	101.67
Zinc 0.7 % × Pusa Bahar	107.67
Zinc 0.7 % × Pusa Narangi Gainda	85.00
Zinc 0.8 % × Pusa Arpita	118.00
Zinc 0.8 % × Pusa Deep	84.67
Zinc 0.8 % × Pusa Basanti Gainda	102.33
Zinc 0.8 % × Pusa Bahar	108.00
Zinc 0.8 % × Pusa Narangi Gainda	86.00
Zinc 1.0 % × Pusa Arpita	119.00
Zinc 1.0 % × Pusa Deep	86.00
Zinc 1.0 % × Pusa Basanti Gainda	103.67
Zinc 1.0 % × Pusa Bahar	109.00
Zinc 1.0 % × Pusa Narangi Gainda	88.67
C.D at 5 %	3.63

Table 4.1.2.2: Effect of different level of zinc on flower initiation (days) in marigold

Treatments	Flower Initiation (days)
Control (Zinc 0.0 %)	115.73
Zinc 0.5 %	107.87
Zinc 0.7 %	109.80
Zinc 0.8%	110.73
Zinc 1.0 %	112.80
C.D at 5 %	1.75
Pusa Arpita	124.53
Pusa Deep	85.00
Pusa Basanti Gainda	123.60
Pusa Bahar	123.87
Pusa Narangi Gainda	99.93
C.D at 5 %	1.75
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	128.00
Zinc 0.0 % × Pusa Deep	93.00
Zinc 0.0 % × Pusa Basanti Gainda	126.33
Zinc 0.0 % × Pusa Bahar	128.33
Zinc 0.0 % × Pusa Narangi Gainda	103.00
Zinc 0.5 % × Pusa Arpita	120.67
Zinc 0.5 % × Pusa Deep	81.00
Zinc 0.5 % × Pusa Basanti Gainda	121.00
Zinc 0.5 % × Pusa Bahar	120.00
Zinc 0.5 % × Pusa Narangi Gainda	96.67
Zinc 0.7 % × Pusa Arpita	123.00
Zinc 0.7 % × Pusa Deep	82.67
Zinc 0.7 % × Pusa Basanti Gainda	122.00
Zinc 0.7 % × Pusa Bahar	122.67
Zinc 0.7 % × Pusa Narangi Gainda	98.67
Zinc 0.8 % × Pusa Arpita	124.33
Zinc 0.8 % × Pusa Deep	83.00
Zinc 0.8 % × Pusa Basanti Gainda	123.00
Zinc 0.8 % × Pusa Bahar	123.67
Zinc 0.8 % × Pusa Narangi Gainda	99.67
Zinc 1.0 % × Pusa Arpita	126.67
Zinc 1.0 % × Pusa Deep	85.33
Zinc 1.0 % × Pusa Basanti Gainda	125.67
Zinc 1.0 % × Pusa Bahar	124.67
Zinc 1.0 % × Pusa Narangi Gainda	101.67
C.D at 5 %	NS

Table 4.1.2.3: Effect of different level of zinc on number of flowers per plant in marigold

Treatments	No. of flowers/plant
Control (Zinc 0.0 %)	29.77
Zinc 0.5 %	46.04
Zinc 0.7 %	35.77
Zinc 0.8%	36.18
Zinc 1.0 %	34.67
C.D at 5 %	1.88
Pusa Arpita	35.48
Pusa Deep	55.27
Pusa Basanti Gainda	32.05
Pusa Bahar	26.54
Pusa Narangi Gainda	33.08
C.D at 5 %	1.88
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	31.69
Zinc 0.0 % × Pusa Deep	41.94
Zinc 0.0 % × Pusa Basanti Gainda	25.45
Zinc 0.0 % × Pusa Bahar	23.08
Zinc 0.0 % × Pusa Narangi Gainda	26.67
Zinc 0.5 % × Pusa Arpita	40.35
Zinc 0.5 % × Pusa Deep	72.05
Zinc 0.5 % × Pusa Basanti Gainda	37.89
Zinc 0.5 % × Pusa Bahar	34.96
Zinc 0.5 % × Pusa Narangi Gainda	44.94
Zinc 0.7 % × Pusa Arpita	35.38
Zinc 0.7 % × Pusa Deep	52.75
Zinc 0.7 % × Pusa Basanti Gainda	32.08
Zinc 0.7 % × Pusa Bahar	25.07
Zinc 0.7 % × Pusa Narangi Gainda	33.55
Zinc 0.8 % × Pusa Arpita	33.57
Zinc 0.8 % × Pusa Deep	57.30
Zinc 0.8 % × Pusa Basanti Gainda	34.01
Zinc 0.8 % × Pusa Bahar	24.96
Zinc 0.8 % × Pusa Narangi Gainda	31.08
Zinc 1.0 % × Pusa Arpita	36.43
Zinc 1.0 % × Pusa Deep	52.29
Zinc 1.0 % × Pusa Basanti Gainda	30.84
Zinc 1.0 % × Pusa Bahar	24.63
Zinc 1.0 % × Pusa Narangi Gainda	29.15
C.D at 5 %	4.21

Table 4.1.2.4: Effect of different level of zinc on number of buds per plant in marigold

Treatments	No. of Buds/Plant
Control (Zinc 0.0 %)	42.92
Zinc 0.5 %	59.99
Zinc 0.7 %	47.46
Zinc 0.8%	47.98
Zinc 1.0 %	48.00
C.D at 5 %	2.80
Pusa Arpita	47.45
Pusa Deep	72.71
Pusa Basanti Gainda	39.79
Pusa Bahar	37.76
Pusa Narangi Gainda	48.62
C.D at 5 %	2.80
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	41.88
Zinc 0.0 % × Pusa Deep	54.87
Zinc 0.0 % × Pusa Basanti Gainda	40.07
Zinc 0.0 % × Pusa Bahar	35.64
Zinc 0.0 % × Pusa Narangi Gainda	42.11
Zinc 0.5 % × Pusa Arpita	55.62
Zinc 0.5 % × Pusa Deep	88.78
Zinc 0.5 % × Pusa Basanti Gainda	48.70
Zinc 0.5 % × Pusa Bahar	46.82
Zinc 0.5 % × Pusa Narangi Gainda	60.03
Zinc 0.7 % × Pusa Arpita	45.17
Zinc 0.7 % × Pusa Deep	68.26
Zinc 0.7 % × Pusa Basanti Gainda	36.06
Zinc 0.7 % × Pusa Bahar	36.58
Zinc 0.7 % × Pusa Narangi Gainda	51.21
Zinc 0.8 % × Pusa Arpita	45.74
Zinc 0.8 % × Pusa Deep	73.67
Zinc 0.8 % × Pusa Basanti Gainda	36.84
Zinc 0.8 % × Pusa Bahar	36.94
Zinc 0.8 % × Pusa Narangi Gainda	46.68
Zinc 1.0 % × Pusa Arpita	48.84
Zinc 1.0 % × Pusa Deep	77.98
Zinc 1.0 % × Pusa Basanti Gainda	37.27
Zinc 1.0 % × Pusa Bahar	32.80
Zinc 1.0 % × Pusa Narangi Gainda	43.08
C.D at 5 %	6.26

Table 4.1.2.5: Effect of different level of zinc on bud length (mm) in marigold

Treatments	Bud length (mm)
Control (Zinc 0.0 %)	16.70
Zinc 0.5 %	19.02
Zinc 0.7 %	17.02
Zinc 0.8%	17.50
Zinc 1.0 %	16.06
C.D at 5 %	0.68
Pusa Arpita	14.01
Pusa Deep	15.50
Pusa Basanti Gainda	19.50
Pusa Bahar	17.60
Pusa Narangi Gainda	19.68
C.D at 5 %	0.68
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	15.19
Zinc 0.0 % × Pusa Deep	13.52
Zinc 0.0 % × Pusa Basanti Gainda	19.27
Zinc 0.0 % × Pusa Bahar	17.54
Zinc 0.0 % × Pusa Narangi Gainda	17.99
Zinc 0.5 % × Pusa Arpita	15.82
Zinc 0.5 % × Pusa Deep	19.30
Zinc 0.5 % × Pusa Basanti Gainda	18.68
Zinc 0.5 % × Pusa Bahar	19.52
Zinc 0.5 % × Pusa Narangi Gainda	21.78
Zinc 0.7 % × Pusa Arpita	12.65
Zinc 0.7 % × Pusa Deep	14.27
Zinc 0.7 % × Pusa Basanti Gainda	19.49
Zinc 0.7 % × Pusa Bahar	19.23
Zinc 0.7 % × Pusa Narangi Gainda	19.46
Zinc 0.8 % × Pusa Arpita	13.39
Zinc 0.8 % × Pusa Deep	15.13
Zinc 0.8 % × Pusa Basanti Gainda	20.19
Zinc 0.8 % × Pusa Bahar	19.39
Zinc 0.8 % × Pusa Narangi Gainda	19.38
Zinc 1.0 % × Pusa Arpita	13.01
Zinc 1.0 % × Pusa Deep	15.28
Zinc 1.0 % × Pusa Basanti Gainda	19.88
Zinc 1.0 % × Pusa Bahar	12.33
Zinc 1.0 % × Pusa Narangi Gainda	19.78
C.D at 5 %	1.53

Table 4.1.2.6: Effect of different level of zinc on bud diameter (mm) in marigold

Treatments	Bud diameter (mm)
Control (Zinc 0.0 %)	11.11
Zinc 0.5 %	13.99
Zinc 0.7 %	12.27
Zinc 0.8%	13.25
Zinc 1.0 %	12.53
C.D at 5 %	1.26
Pusa Arpita	9.31
Pusa Deep	9.73
Pusa Basanti Gainda	16.53
Pusa Bahar	14.23
Pusa Narangi Gainda	13.36
C.D at 5 %	1.26
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	6.65
Zinc 0.0 % × Pusa Deep	8.85
Zinc 0.0 % × Pusa Basanti Gainda	16.37
Zinc 0.0 % × Pusa Bahar	13.96
Zinc 0.0 % × Pusa Narangi Gainda	9.74
Zinc 0.5 % × Pusa Arpita	11.37
Zinc 0.5 % × Pusa Deep	11.51
Zinc 0.5 % × Pusa Basanti Gainda	17.50
Zinc 0.5 % × Pusa Bahar	14.96
Zinc 0.5 % × Pusa Narangi Gainda	14.60
Zinc 0.7 % × Pusa Arpita	8.99
Zinc 0.7 % × Pusa Deep	8.87
Zinc 0.7 % × Pusa Basanti Gainda	15.11
Zinc 0.7 % × Pusa Bahar	14.51
Zinc 0.7 % × Pusa Narangi Gainda	13.88
Zinc 0.8 % × Pusa Arpita	9.53
Zinc 0.8 % × Pusa Deep	9.61
Zinc 0.8 % × Pusa Basanti Gainda	17.93
Zinc 0.8 % × Pusa Bahar	14.69
Zinc 0.8 % × Pusa Narangi Gainda	14.49
Zinc 1.0 % × Pusa Arpita	10.00
Zinc 1.0 % × Pusa Deep	9.83
Zinc 1.0 % × Pusa Basanti Gainda	15.73
Zinc 1.0 % × Pusa Bahar	13.04
Zinc 1.0 % × Pusa Narangi Gainda	14.07
C.D at 5 %	NS

Table 4.1.2.7: Effect of different level of zinc on flower diameter (mm) in marigold

Treatments	Flower diameter (mm)
Control (Zinc 0.0 %)	53.53
Zinc 0.5 %	56.76
Zinc 0.7 %	53.44
Zinc 0.8%	53.48
Zinc 1.0 %	54.57
C.D at 5 %	1.56
Pusa Arpita	48.64
Pusa Deep	49.73
Pusa Basanti Gainda	63.56
Pusa Bahar	51.46
Pusa Narangi Gainda	58.39
C.D at 5 %	1.56
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	46.02
Zinc 0.0 % × Pusa Deep	50.29
Zinc 0.0 % × Pusa Basanti Gainda	65.37
Zinc 0.0 % × Pusa Bahar	48.22
Zinc 0.0 % × Pusa Narangi Gainda	57.74
Zinc 0.5 % × Pusa Arpita	50.43
Zinc 0.5 % × Pusa Deep	51.14
Zinc 0.5 % × Pusa Basanti Gainda	68.03
Zinc 0.5 % × Pusa Bahar	53.62
Zinc 0.5 % × Pusa Narangi Gainda	60.58
Zinc 0.7 % × Pusa Arpita	48.83
Zinc 0.7 % × Pusa Deep	51.04
Zinc 0.7 % × Pusa Basanti Gainda	58.35
Zinc 0.7 % × Pusa Bahar	50.78
Zinc 0.7 % × Pusa Narangi Gainda	58.20
Zinc 0.8 % × Pusa Arpita	48.98
Zinc 0.8 % × Pusa Deep	47.25
Zinc 0.8 % × Pusa Basanti Gainda	66.45
Zinc 0.8 % × Pusa Bahar	48.96
Zinc 0.8 % × Pusa Narangi Gainda	55.73
Zinc 1.0 % × Pusa Arpita	48.95
Zinc 1.0 % × Pusa Deep	48.91
Zinc 1.0 % × Pusa Basanti Gainda	59.61
Zinc 1.0 % × Pusa Bahar	55.69
Zinc 1.0 % × Pusa Narangi Gainda	59.70
C.D at 5 %	3.48

Table 4.1.2.8: Effect of different level of zinc on peduncle length (cm) in marigold

Treatments	Peduncle Length (cm)
Control (Zinc 0.0 %)	7.48
Zinc 0.5 %	7.85
Zinc 0.7 %	7.47
Zinc 0.8%	7.36
Zinc 1.0 %	7.01
C.D at 5 %	0.41
Pusa Arpita	6.51
Pusa Deep	6.87
Pusa Basanti Gainda	9.39
Pusa Bahar	7.31
Pusa Narangi Gainda	7.09
C.D at 5 %	0.41
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	6.09
Zinc 0.0 % × Pusa Deep	6.60
Zinc 0.0 % × Pusa Basanti Gainda	10.43
Zinc 0.0 % × Pusa Bahar	6.89
Zinc 0.0 % × Pusa Narangi Gainda	7.37
Zinc 0.5 % × Pusa Arpita	7.17
Zinc 0.5 % × Pusa Deep	7.30
Zinc 0.5 % × Pusa Basanti Gainda	9.56
Zinc 0.5 % × Pusa Bahar	7.50
Zinc 0.5 % × Pusa Narangi Gainda	7.74
Zinc 0.7 % × Pusa Arpita	6.87
Zinc 0.7 % × Pusa Deep	7.30
Zinc 0.7 % × Pusa Basanti Gainda	8.46
Zinc 0.7 % × Pusa Bahar	7.82
Zinc 0.7 % × Pusa Narangi Gainda	6.87
Zinc 0.8 % × Pusa Arpita	6.99
Zinc 0.8 % × Pusa Deep	7.23
Zinc 0.8 % × Pusa Basanti Gainda	8.89
Zinc 0.8 % × Pusa Bahar	6.90
Zinc 0.8 % × Pusa Narangi Gainda	6.79
Zinc 1.0 % × Pusa Arpita	5.41
Zinc 1.0 % × Pusa Deep	5.93
Zinc 1.0 % × Pusa Basanti Gainda	9.60
Zinc 1.0 % × Pusa Bahar	7.43
Zinc 1.0 % × Pusa Narangi Gainda	6.69
C.D at 5 %	0.92

Table 4.1.2.9: Effect of different level of zinc on fresh weight of flowers (g) in marigold

Treatments	Fresh wt. of flowers (g)
Control (Zinc 0.0 %)	4.67
Zinc 0.5 %	6.03
Zinc 0.7 %	4.68
Zinc 0.8%	5.00
Zinc 1.0 %	4.69
C.D at 5 %	0.31
Pusa Arpita	3.95
Pusa Deep	3.82
Pusa Basanti Gainda	5.95
Pusa Bahar	5.85
Pusa Narangi Gainda	5.49
C.D at 5 %	0.31
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	3.77
Zinc 0.0 % × Pusa Deep	3.82
Zinc 0.0 % × Pusa Basanti Gainda	5.73
Zinc 0.0 % × Pusa Bahar	5.48
Zinc 0.0 % × Pusa Narangi Gainda	4.53
Zinc 0.5 % × Pusa Arpita	4.63
Zinc 0.5 % × Pusa Deep	4.18
Zinc 0.5 % × Pusa Basanti Gainda	7.68
Zinc 0.5 % × Pusa Bahar	6.87
Zinc 0.5 % × Pusa Narangi Gainda	6.80
Zinc 0.7 % × Pusa Arpita	3.66
Zinc 0.7 % × Pusa Deep	3.90
Zinc 0.7 % × Pusa Basanti Gainda	4.81
Zinc 0.7 % × Pusa Bahar	6.17
Zinc 0.7 % × Pusa Narangi Gainda	4.84
Zinc 0.8 % × Pusa Arpita	3.66
Zinc 0.8 % × Pusa Deep	3.84
Zinc 0.8 % × Pusa Basanti Gainda	6.17
Zinc 0.8 % × Pusa Bahar	5.66
Zinc 0.8 % × Pusa Narangi Gainda	5.66
Zinc 1.0 % × Pusa Arpita	4.03
Zinc 1.0 % × Pusa Deep	3.37
Zinc 1.0 % × Pusa Basanti Gainda	5.34
Zinc 1.0 % × Pusa Bahar	5.06
Zinc 1.0 % × Pusa Narangi Gainda	5.62
C.D at 5 %	0.68

Table 4.1.2.10: Effect of different level of zinc on dry weight of flowers (g) in marigold

Treatments	Dry wt. of flowers (g)
Control (Zinc 0.0 %)	0.59
Zinc 0.5 %	0.74
Zinc 0.7 %	0.61
Zinc 0.8%	0.73
Zinc 1.0 %	0.64
C.D at 5 %	0.06
Pusa Arpita	0.46
Pusa Deep	0.50
Pusa Basanti Gainda	0.87
Pusa Bahar	0.80
Pusa Narangi Gainda	0.69
C.D at 5 %	0.06
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	0.40
Zinc 0.0 % × Pusa Deep	0.51
Zinc 0.0 % × Pusa Basanti Gainda	0.83
Zinc 0.0 % × Pusa Bahar	0.70
Zinc 0.0 % × Pusa Narangi Gainda	0.53
Zinc 0.5 % × Pusa Arpita	0.43
Zinc 0.5 % × Pusa Deep	0.51
Zinc 0.5 % × Pusa Basanti Gainda	1.08
Zinc 0.5 % × Pusa Bahar	0.85
Zinc 0.5 % × Pusa Narangi Gainda	0.81
Zinc 0.7 % × Pusa Arpita	0.43
Zinc 0.7 % × Pusa Deep	0.50
Zinc 0.7 % × Pusa Basanti Gainda	0.70
Zinc 0.7 % × Pusa Bahar	0.79
Zinc 0.7 % × Pusa Narangi Gainda	0.64
Zinc 0.8 % × Pusa Arpita	0.54
Zinc 0.8 % × Pusa Deep	0.53
Zinc 0.8 % × Pusa Basanti Gainda	0.93
Zinc 0.8 % × Pusa Bahar	0.89
Zinc 0.8 % × Pusa Narangi Gainda	0.78
Zinc 1.0 % × Pusa Arpita	0.49
Zinc 1.0 % × Pusa Deep	0.45
Zinc 1.0 % × Pusa Basanti Gainda	0.79
Zinc 1.0 % × Pusa Bahar	0.79
Zinc 1.0 % × Pusa Narangi Gainda	0.67
C.D at 5 %	0.13

Table 4.1.2.11: Effect of different level of zinc on flower yield per plot (kg) in marigold

Treatments	Flower yield/Plot (kg)
Control (Zinc 0.0 %)	1.28
Zinc 0.5 %	1.62
Zinc 0.7 %	1.23
Zinc 0.8%	1.48
Zinc 1.0 %	1.32
C.D at 5 %	0.15
Pusa Arpita	0.93
Pusa Deep	1.75
Pusa Basanti Gainda	1.29
Pusa Bahar	1.37
Pusa Narangi Gainda	1.60
C.D at 5 %	0.15
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	0.87
Zinc 0.0 % × Pusa Deep	1.67
Zinc 0.0 % × Pusa Basanti Gainda	0.95
Zinc 0.0 % × Pusa Bahar	1.30
Zinc 0.0 % × Pusa Narangi Gainda	1.62
Zinc 0.5 % × Pusa Arpita	1.24
Zinc 0.5 % × Pusa Deep	1.90
Zinc 0.5 % × Pusa Basanti Gainda	1.65
Zinc 0.5 % × Pusa Bahar	1.54
Zinc 0.5 % × Pusa Narangi Gainda	1.75
Zinc 0.7 % × Pusa Arpita	0.87
Zinc 0.7 % × Pusa Deep	1.77
Zinc 0.7 % × Pusa Basanti Gainda	1.05
Zinc 0.7 % × Pusa Bahar	1.20
Zinc 0.7 % × Pusa Narangi Gainda	1.27
Zinc 0.8 % × Pusa Arpita	0.72
Zinc 0.8 % × Pusa Deep	1.83
Zinc 0.8 % × Pusa Basanti Gainda	1.64
Zinc 0.8 % × Pusa Bahar	1.52
Zinc 0.8 % × Pusa Narangi Gainda	1.71
Zinc 1.0 % × Pusa Arpita	0.95
Zinc 1.0 % × Pusa Deep	1.60
Zinc 1.0 % × Pusa Basanti Gainda	1.14
Zinc 1.0 % × Pusa Bahar	1.29
Zinc 1.0 % × Pusa Narangi Gainda	1.63
C.D at 5 %	NS

Table 4.1.3.1: Effect of different level of zinc on number of seeds per flower in marigold

Treatments	No. of seed/flower
Control (Zinc 0.0 %)	194.80
Zinc 0.5 %	243.60
Zinc 0.7 %	198.95
Zinc 0.8%	206.46
Zinc 1.0 %	205.58
C.D at 5 %	16.38
Pusa Arpita	226.77
Pusa Deep	118.09
Pusa Basanti Gainda	256.53
Pusa Bahar	218.89
Pusa Narangi Gainda	229.10
C.D at 5 %	16.38
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	211.73
Zinc 0.0 % × Pusa Deep	116.11
Zinc 0.0 % × Pusa Basanti Gainda	244.17
Zinc 0.0 % × Pusa Bahar	193.18
Zinc 0.0 % × Pusa Narangi Gainda	208.81
Zinc 0.5 % × Pusa Arpita	266.59
Zinc 0.5 % × Pusa Deep	124.92
Zinc 0.5 % × Pusa Basanti Gainda	318.92
Zinc 0.5 % × Pusa Bahar	240.96
Zinc 0.5 % × Pusa Narangi Gainda	266.59
Zinc 0.7 % × Pusa Arpita	211.44
Zinc 0.7 % × Pusa Deep	110.77
Zinc 0.7 % × Pusa Basanti Gainda	245.29
Zinc 0.7 % × Pusa Bahar	208.88
Zinc 0.7 % × Pusa Narangi Gainda	218.37
Zinc 0.8 % × Pusa Arpita	220.37
Zinc 0.8 % × Pusa Deep	118.59
Zinc 0.8 % × Pusa Basanti Gainda	236.32
Zinc 0.8 % × Pusa Bahar	232.44
Zinc 0.8 % × Pusa Narangi Gainda	224.59
Zinc 1.0 % × Pusa Arpita	223.74
Zinc 1.0 % × Pusa Deep	120.07
Zinc 1.0 % × Pusa Basanti Gainda	237.96
Zinc 1.0 % × Pusa Bahar	218.99
Zinc 1.0 % × Pusa Narangi Gainda	227.14
C.D at 5 %	NS

Table 4.1.3.2: Effect of different level of zinc on seed weight per flower (g) in marigold

Treatments	Seed wt. (g)/flower
Control (Zinc 0.0 %)	0.35
Zinc 0.5 %	0.43
Zinc 0.7 %	0.37
Zinc 0.8%	0.38
Zinc 1.0 %	0.37
C.D at 5 %	0.05
Pusa Arpita	0.24
Pusa Deep	0.34
Pusa Basanti Gainda	0.45
Pusa Bahar	0.49
Pusa Narangi Gainda	0.38
C.D at 5 %	0.05
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	0.26
Zinc 0.0 % × Pusa Deep	0.30
Zinc 0.0 % × Pusa Basanti Gainda	0.40
Zinc 0.0 % × Pusa Bahar	0.46
Zinc 0.0 % × Pusa Narangi Gainda	0.32
Zinc 0.5 % × Pusa Arpita	0.29
Zinc 0.5 % × Pusa Deep	0.37
Zinc 0.5 % × Pusa Basanti Gainda	0.48
Zinc 0.5 % × Pusa Bahar	0.57
Zinc 0.5 % × Pusa Narangi Gainda	0.43
Zinc 0.7 % × Pusa Arpita	0.21
Zinc 0.7 % × Pusa Deep	0.38
Zinc 0.7 % × Pusa Basanti Gainda	0.43
Zinc 0.7 % × Pusa Bahar	0.45
Zinc 0.7 % × Pusa Narangi Gainda	0.37
Zinc 0.8 % × Pusa Arpita	0.22
Zinc 0.8 % × Pusa Deep	0.30
Zinc 0.8 % × Pusa Basanti Gainda	0.46
Zinc 0.8 % × Pusa Bahar	0.50
Zinc 0.8 % × Pusa Narangi Gainda	0.40
Zinc 1.0 % × Pusa Arpita	0.20
Zinc 1.0 % × Pusa Deep	0.35
Zinc 1.0 % × Pusa Basanti Gainda	0.46
Zinc 1.0 % × Pusa Bahar	0.47
Zinc 1.0 % × Pusa Narangi Gainda	0.38
C.D at 5 %	NS

Table 4.1.3.3: Effect of different level of zinc on weight of hundred seeds in marigold

Treatments	Wt. of 100 seed
Control (Zinc 0.0 %)	0.19
Zinc 0.5 %	0.26
Zinc 0.7 %	0.23
Zinc 0.8%	0.23
Zinc 1.0 %	0.21
C.D at 5 %	0.01
Pusa Arpita	0.16
Pusa Deep	0.25
Pusa Basanti Gainda	0.19
Pusa Bahar	0.25
Pusa Narangi Gainda	0.26
C.D at 5 %	0.01
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	0.15
Zinc 0.0 % × Pusa Deep	0.20
Zinc 0.0 % × Pusa Basanti Gainda	0.16
Zinc 0.0 % × Pusa Bahar	0.21
Zinc 0.0 % × Pusa Narangi Gainda	0.25
Zinc 0.5 % × Pusa Arpita	0.18
Zinc 0.5 % × Pusa Deep	0.31
Zinc 0.5 % × Pusa Basanti Gainda	0.23
Zinc 0.5 % × Pusa Bahar	0.28
Zinc 0.5 % × Pusa Narangi Gainda	0.29
Zinc 0.7 % × Pusa Arpita	0.15
Zinc 0.7 % × Pusa Deep	0.26
Zinc 0.7 % × Pusa Basanti Gainda	0.21
Zinc 0.7 % × Pusa Bahar	0.25
Zinc 0.7 % × Pusa Narangi Gainda	0.27
Zinc 0.8 % × Pusa Arpita	0.16
Zinc 0.8 % × Pusa Deep	0.25
Zinc 0.8 % × Pusa Basanti Gainda	0.19
Zinc 0.8 % × Pusa Bahar	0.25
Zinc 0.8 % × Pusa Narangi Gainda	0.26
Zinc 1.0 % × Pusa Arpita	0.16
Zinc 1.0 % × Pusa Deep	0.22
Zinc 1.0 % × Pusa Basanti Gainda	0.18
Zinc 1.0 % × Pusa Bahar	0.25
Zinc 1.0 % × Pusa Narangi Gainda	0.25
C.D at 5 %	0.02

Table 4.1.3.4: Effect of different level of zinc on seed yield per plot in marigold

Treatments	**Seed yield/Plot**
Control (Zinc 0.0 %)	107.42
Zinc 0.5 %	171.71
Zinc 0.7 %	111.47
Zinc 0.8%	129.82
Zinc 1.0 %	126.88
C.D at 5 %	20.67
Pusa Arpita	57.62
Pusa Deep	233.45
Pusa Basanti Gainda	102.92
Pusa Bahar	123.13
Pusa Narangi Gainda	130.19
C.D at 5 %	20.67
Interaction (Zinc × varieties)	
Zinc 0.0 % × Pusa Arpita	49.85
Zinc 0.0 % × Pusa Deep	200.24
Zinc 0.0 % × Pusa Basanti Gainda	95.38
Zinc 0.0 % × Pusa Bahar	94.10
Zinc 0.0 % × Pusa Narangi Gainda	97.55
Zinc 0.5 % × Pusa Arpita	92.62
Zinc 0.5 % × Pusa Deep	326.37
Zinc 0.5 % × Pusa Basanti Gainda	141.58
Zinc 0.5 % × Pusa Bahar	153.96
Zinc 0.5 % × Pusa Narangi Gainda	144.01
Zinc 0.7 % × Pusa Arpita	55.49
Zinc 0.7 % × Pusa Deep	192.86
Zinc 0.7 % × Pusa Basanti Gainda	65.21
Zinc 0.7 % × Pusa Bahar	128.79
Zinc 0.7 % × Pusa Narangi Gainda	115.00
Zinc 0.8 % × Pusa Arpita	43.03
Zinc 0.8 % × Pusa Deep	245.70
Zinc 0.8 % × Pusa Basanti Gainda	114.06
Zinc 0.8 % × Pusa Bahar	118.02
Zinc 0.8 % × Pusa Narangi Gainda	128.30
Zinc 1.0 % × Pusa Arpita	47.10
Zinc 1.0 % × Pusa Deep	202.09
Zinc 1.0 % × Pusa Basanti Gainda	98.38
Zinc 1.0 % × Pusa Bahar	120.76
Zinc 1.0 % × Pusa Narangi Gainda	166.07
C.D at 5 %	0.02

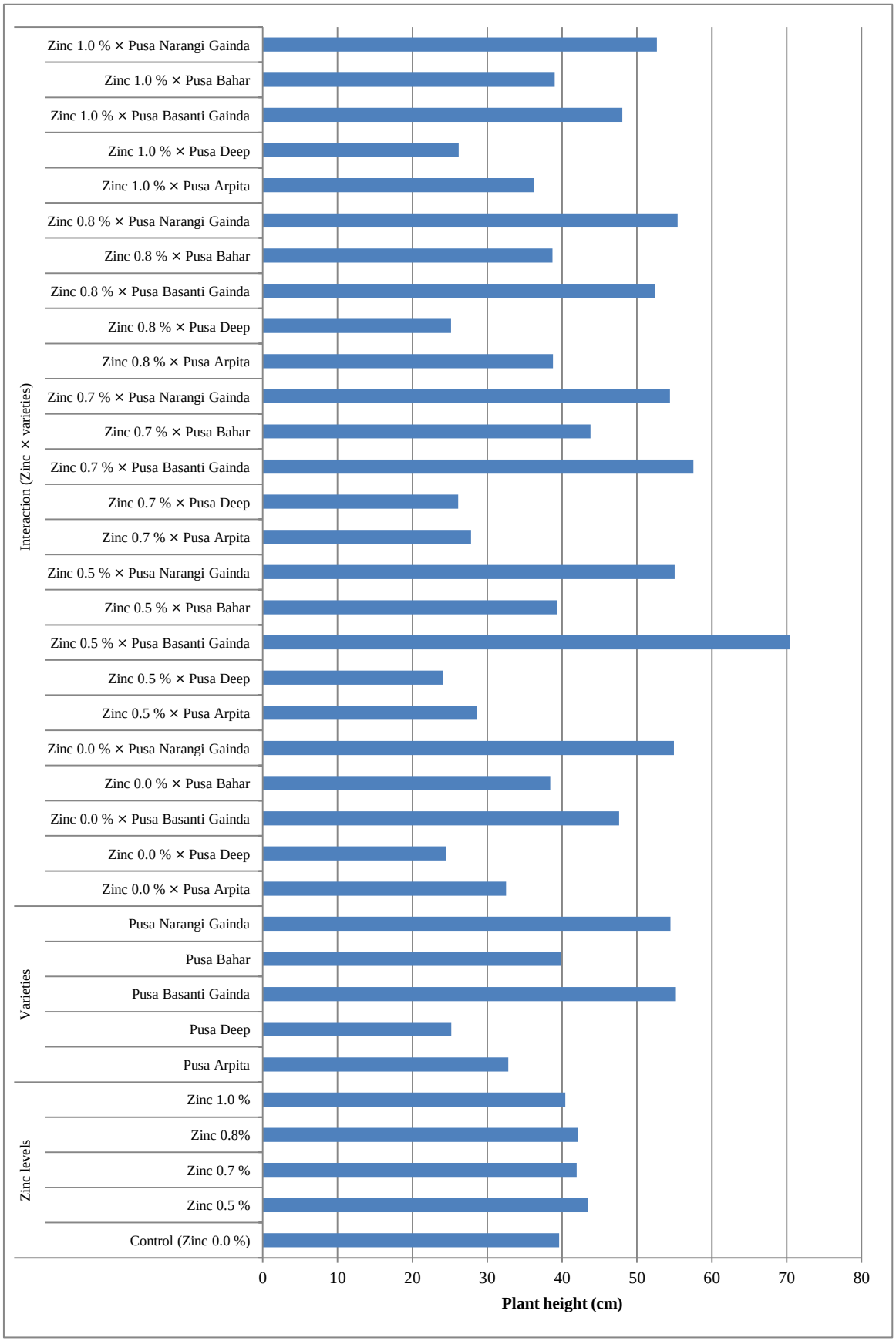


Figure 4.1.1.1. Effect of different level of zinc on plant height (cm) in marigold

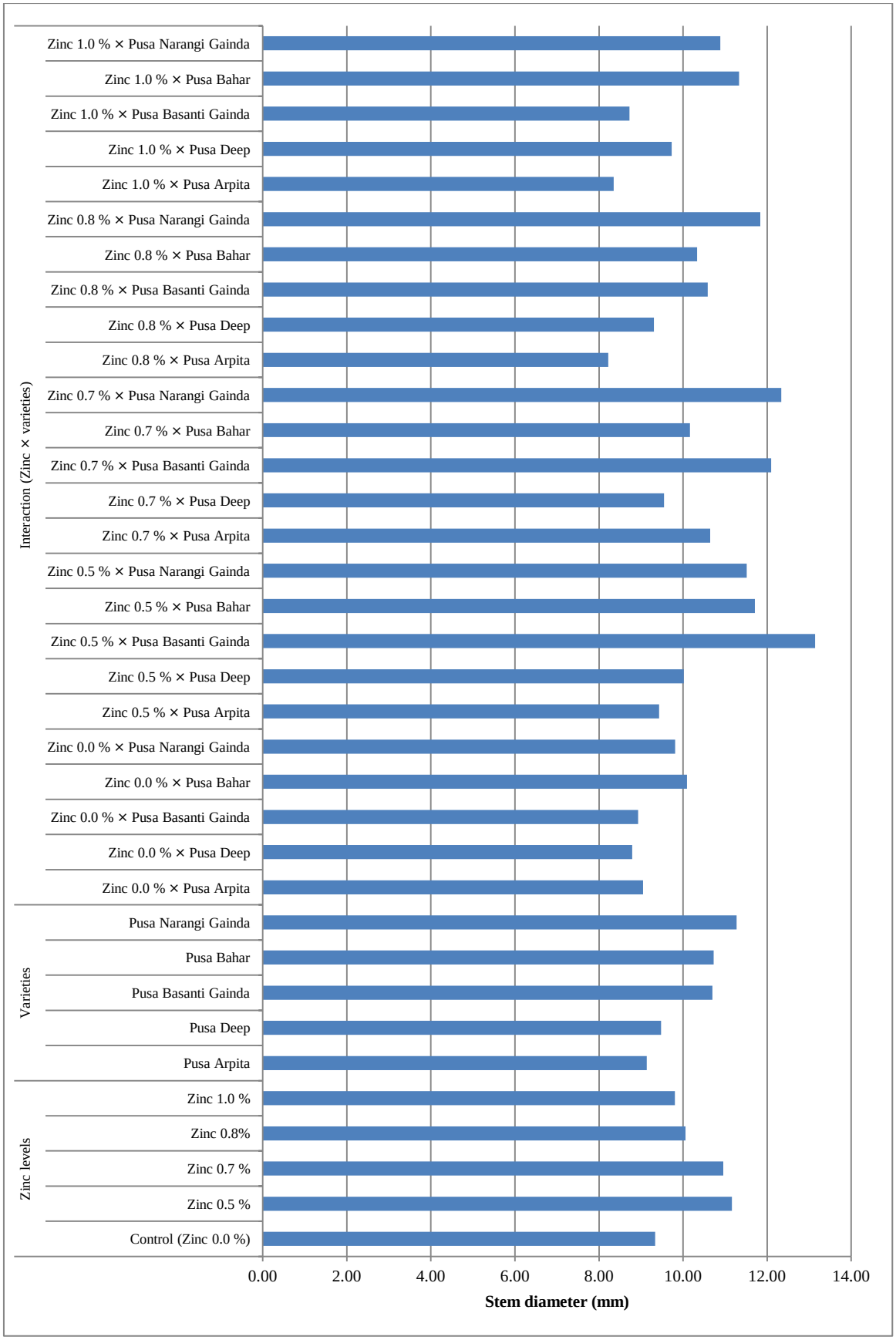


Figure 4.1.1.2. Effect of different level of zinc on stem diameter (mm) **in marigold**

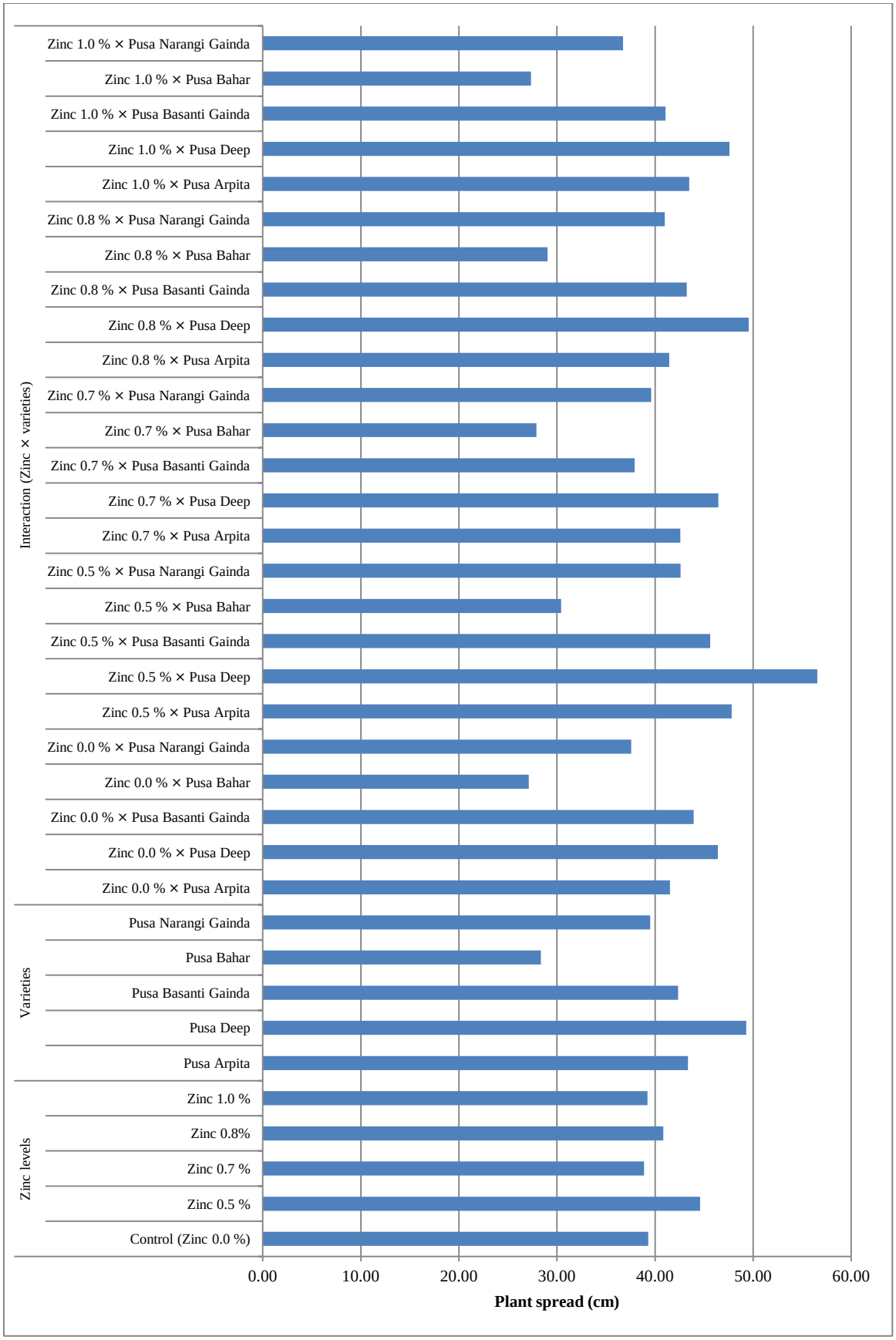


Figure 4.1.1.3. Effect of different level of zinc on plant spread (cm) in marigold

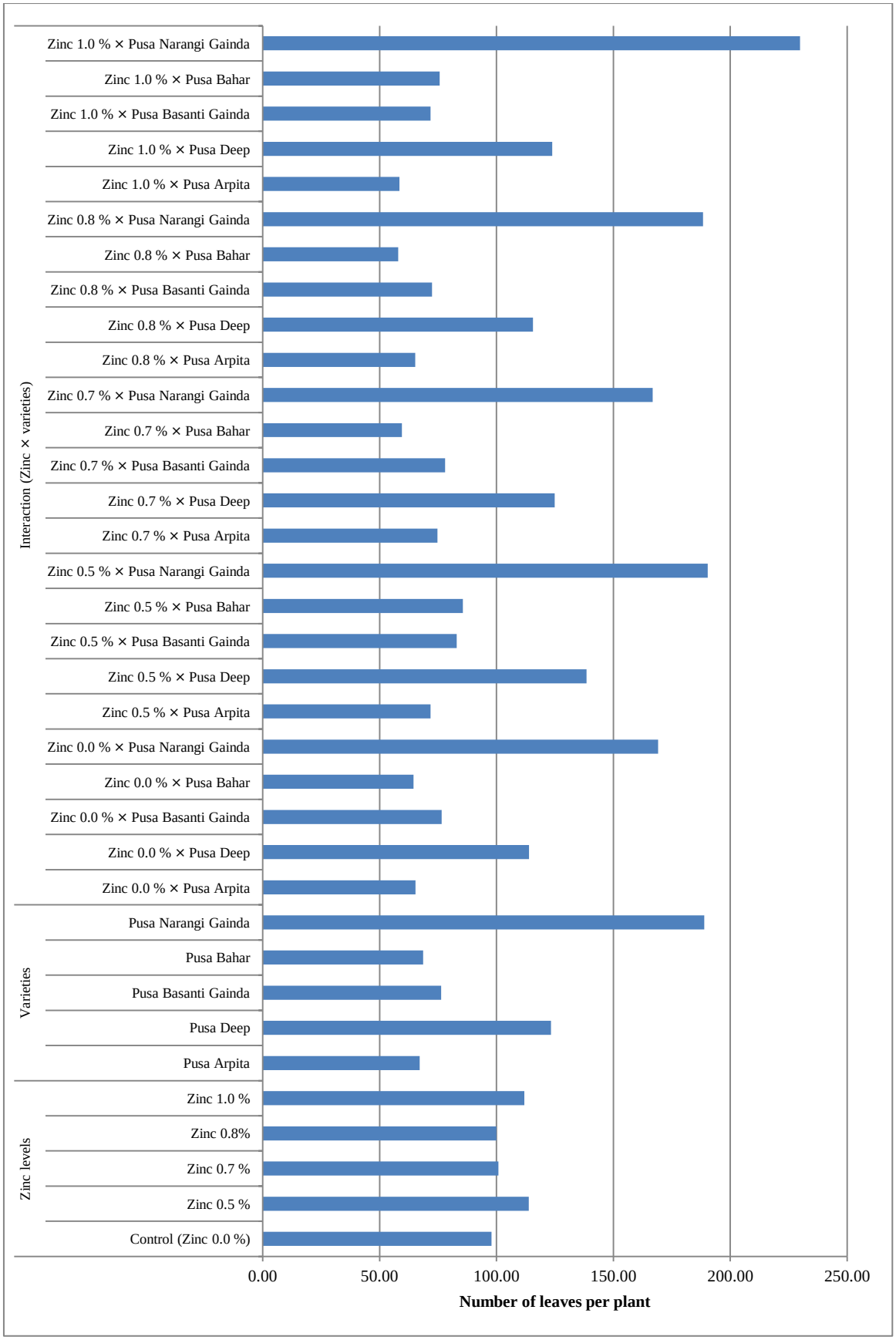


Figure 4.1.1.4. Effect of different level of zinc on number of leaves per plant in marigold

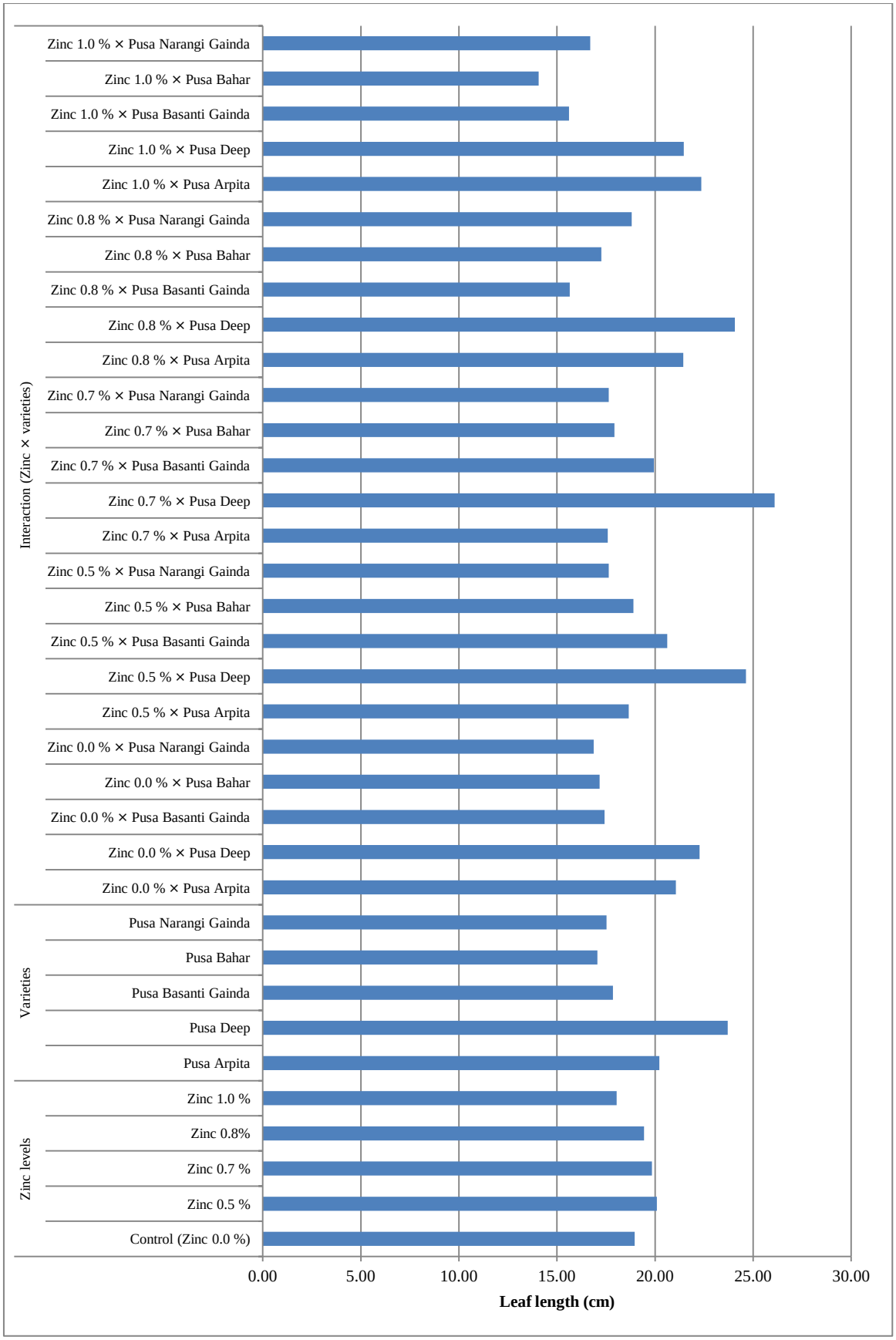


Figure 4.1.1.5. Effect of different level of zinc on leaf length (cm) in marigold

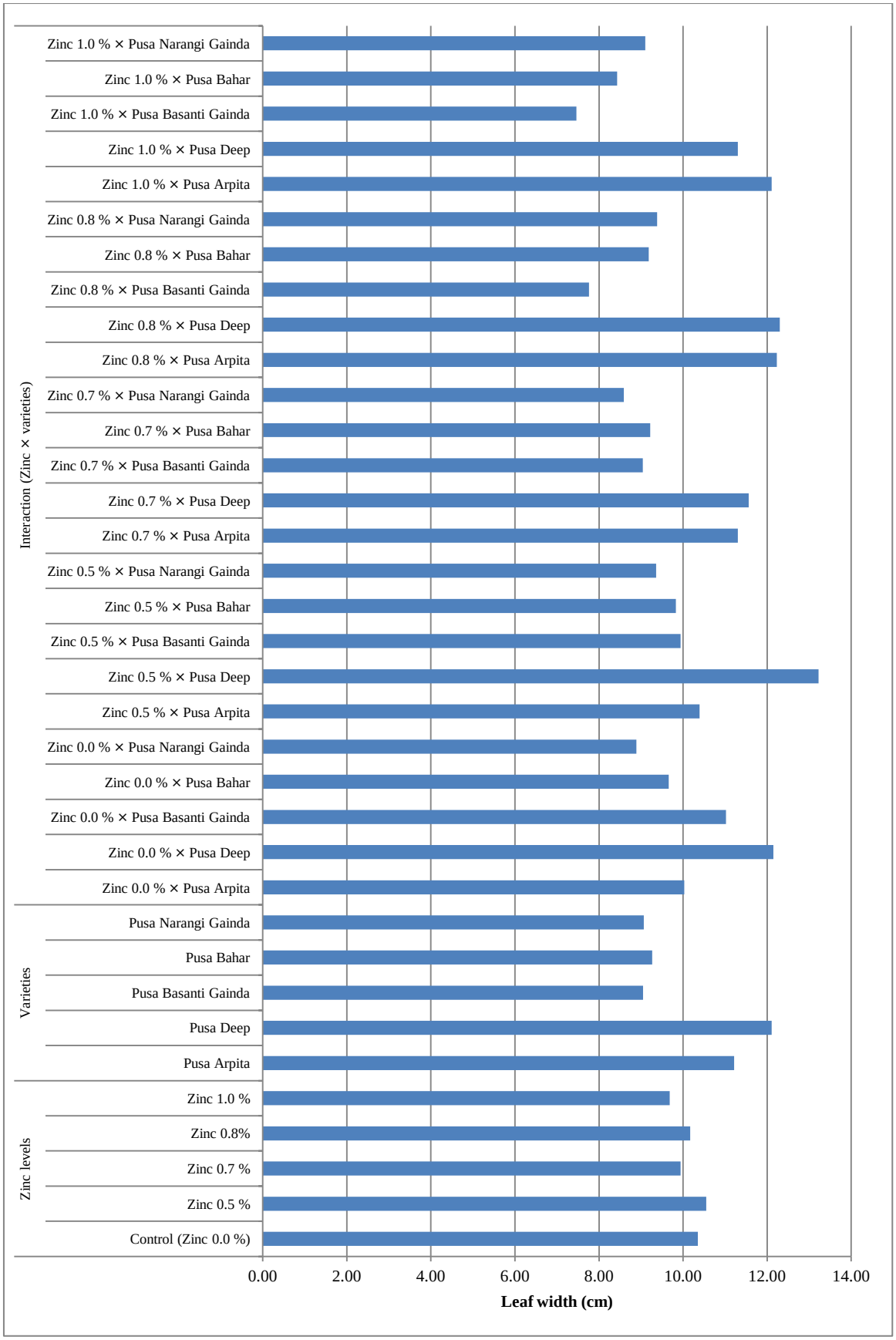


Figure 4.1.1.6. Effect of different level of zinc on leaf width (cm) in marigold

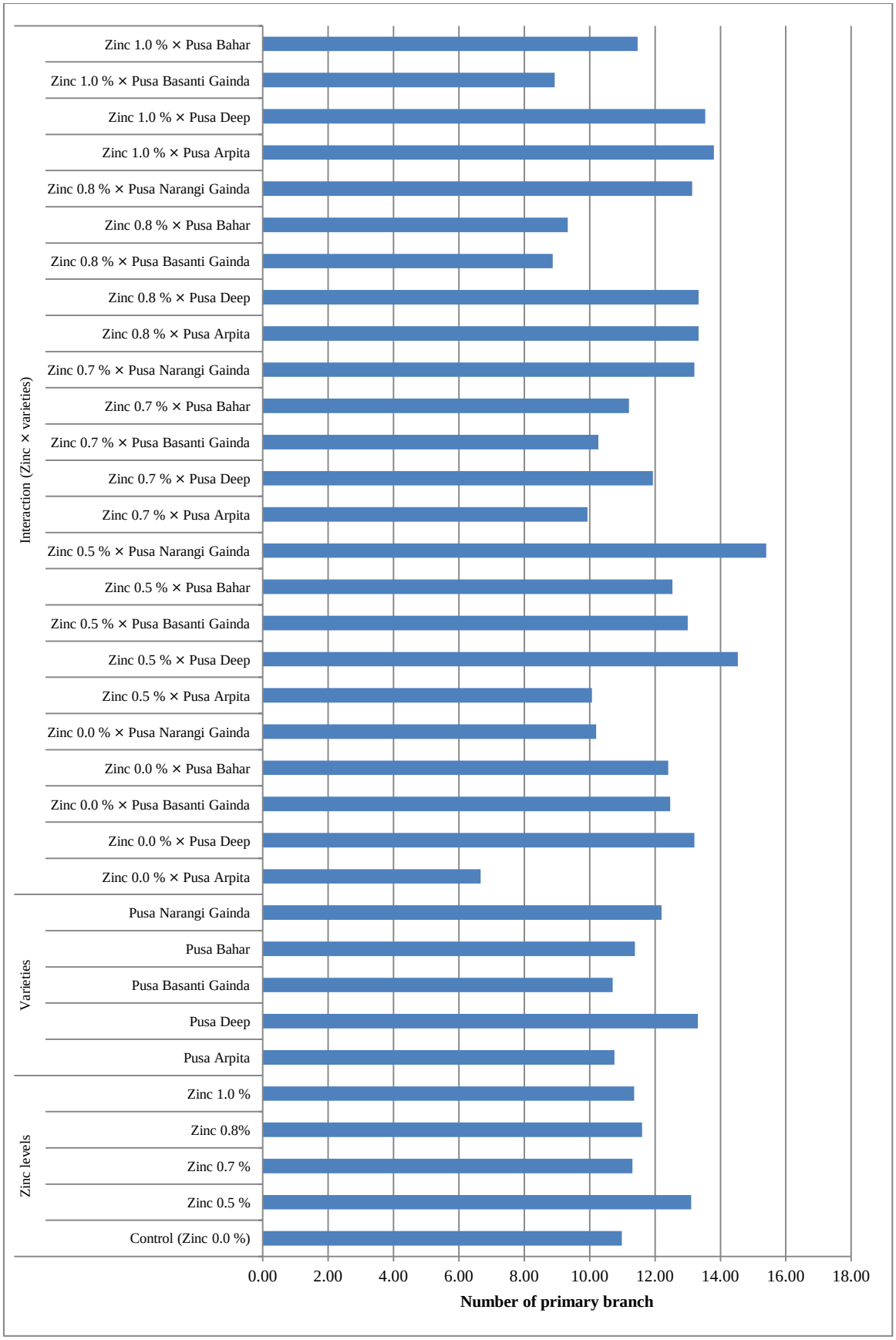


Figure 4.1.1.7. Effect of different level of zinc on number of primary branch in marigold

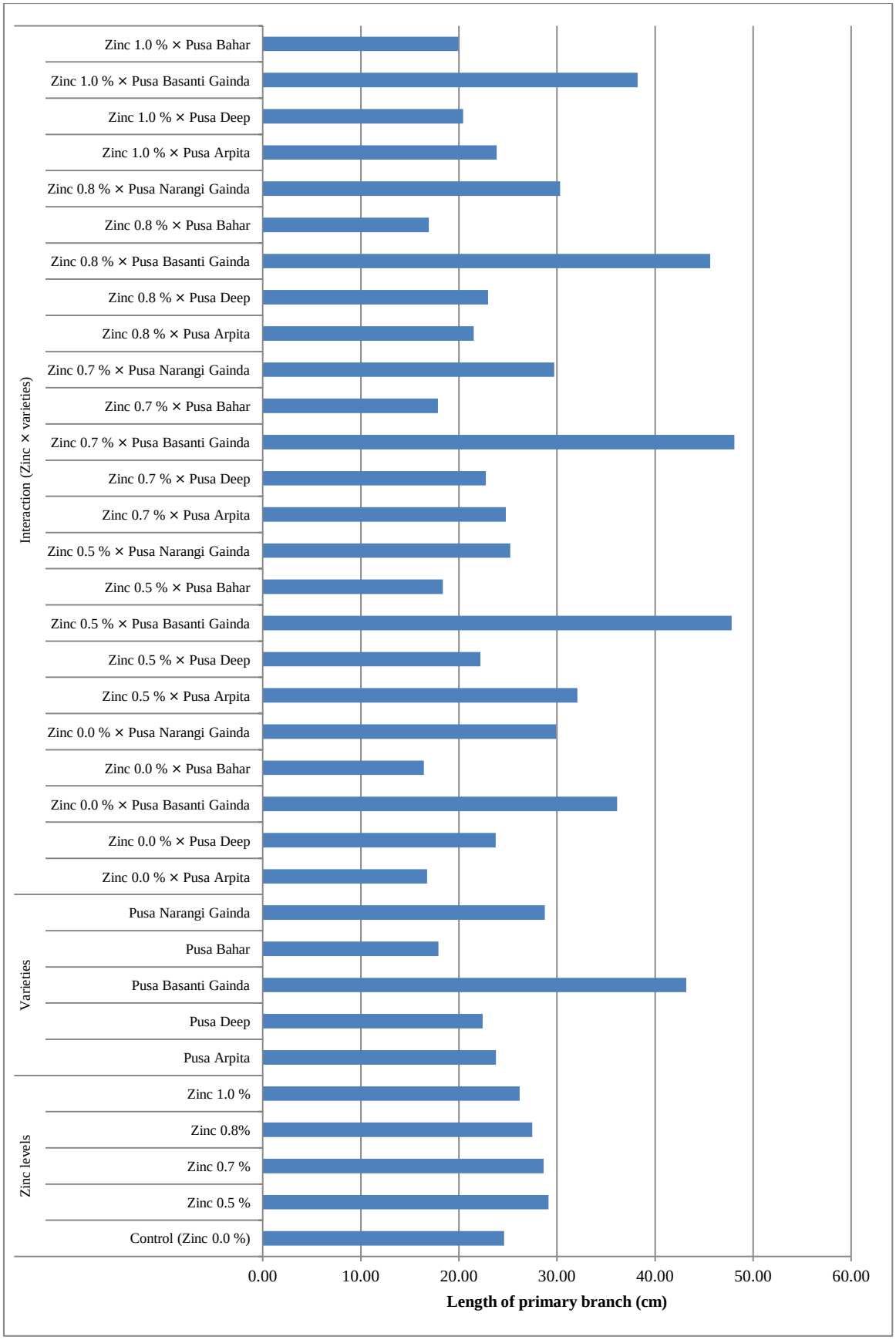


Figure 4.1.1.8. Effect of different level of zinc on length of primary branch (cm) in marigold

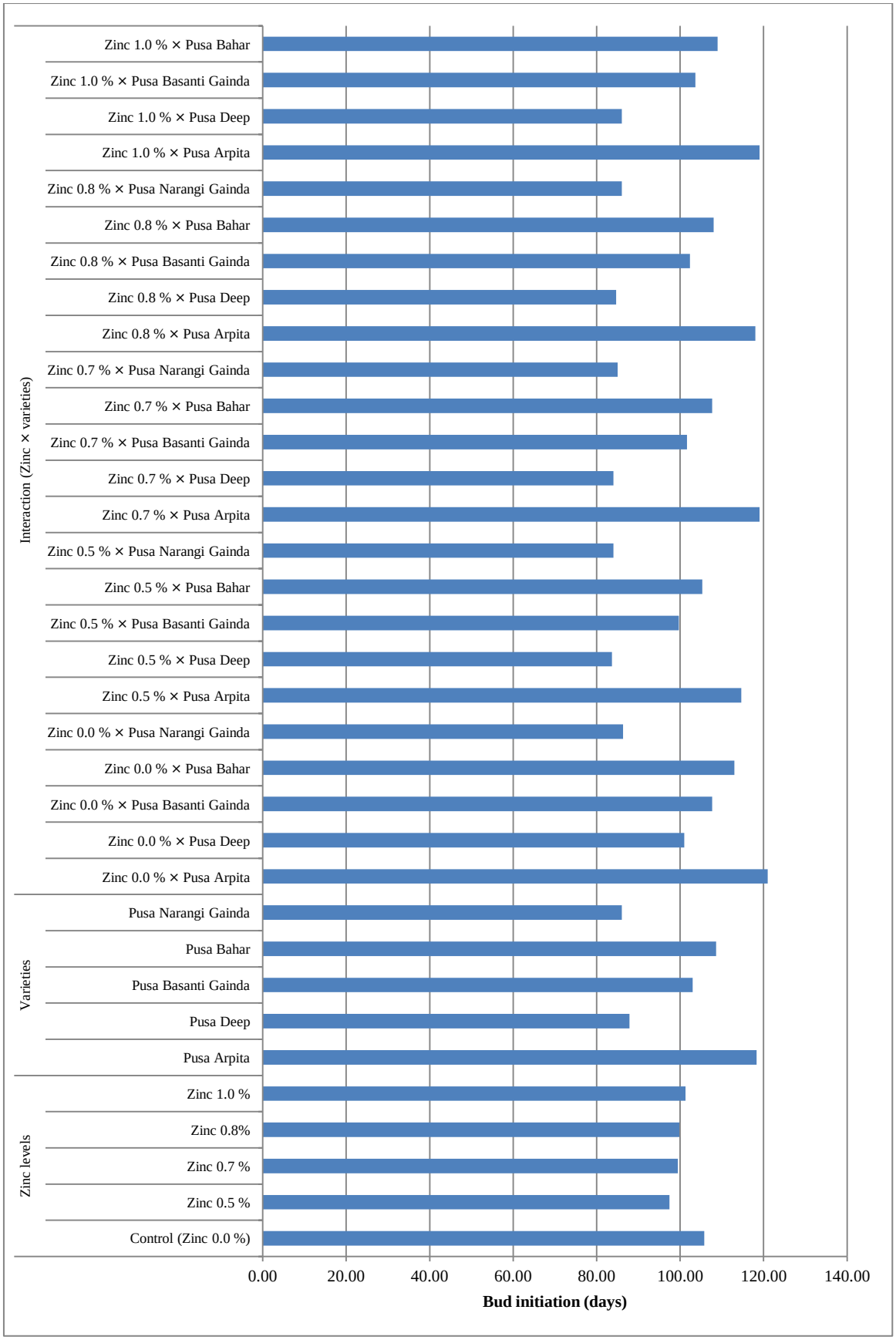


Figure 4.1.2.1. Effect of different level of zinc on bud initiation (days) in marigold

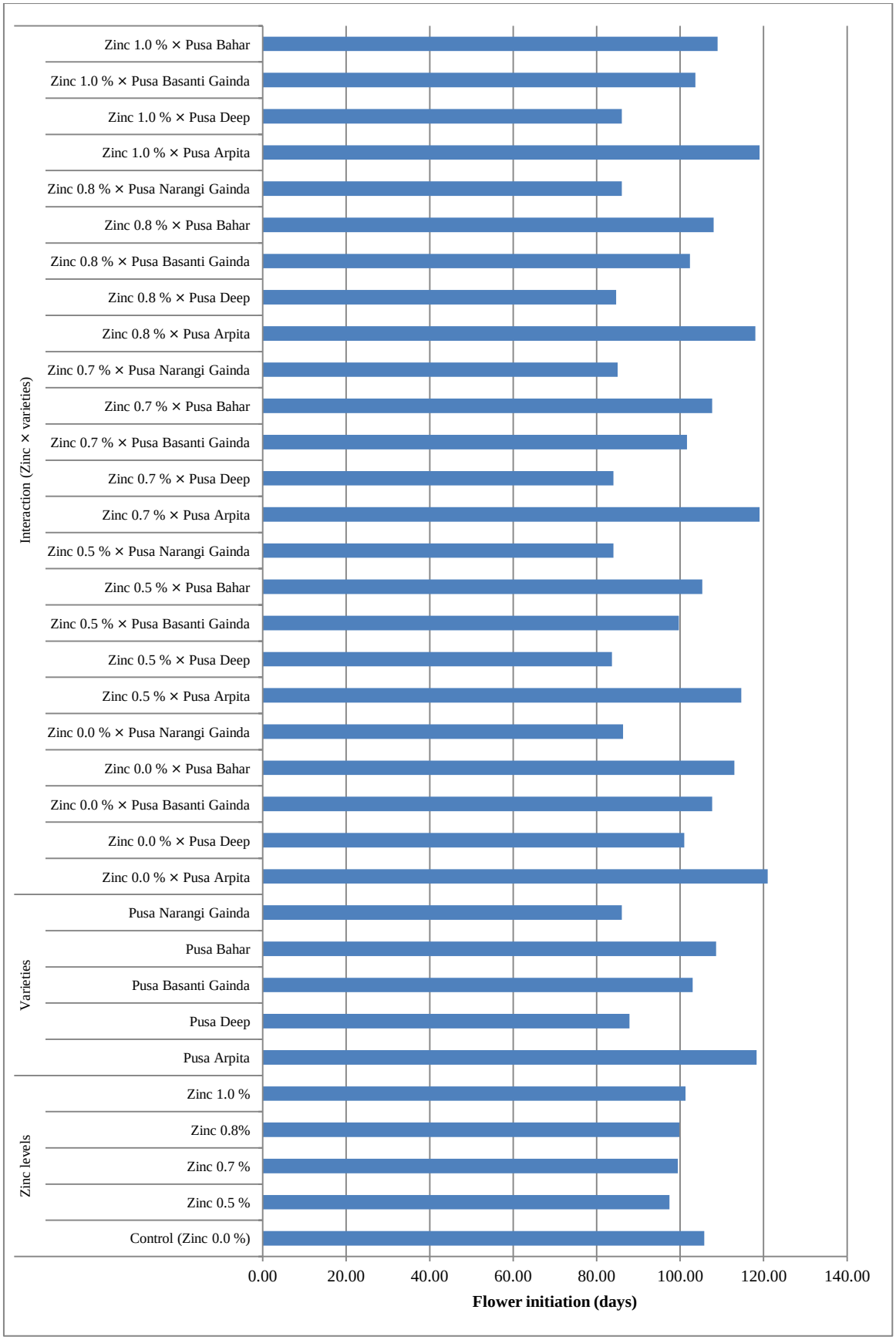


Figure 4.1.2.2. Effect of different level of zinc on flower initiation (days) in marigold

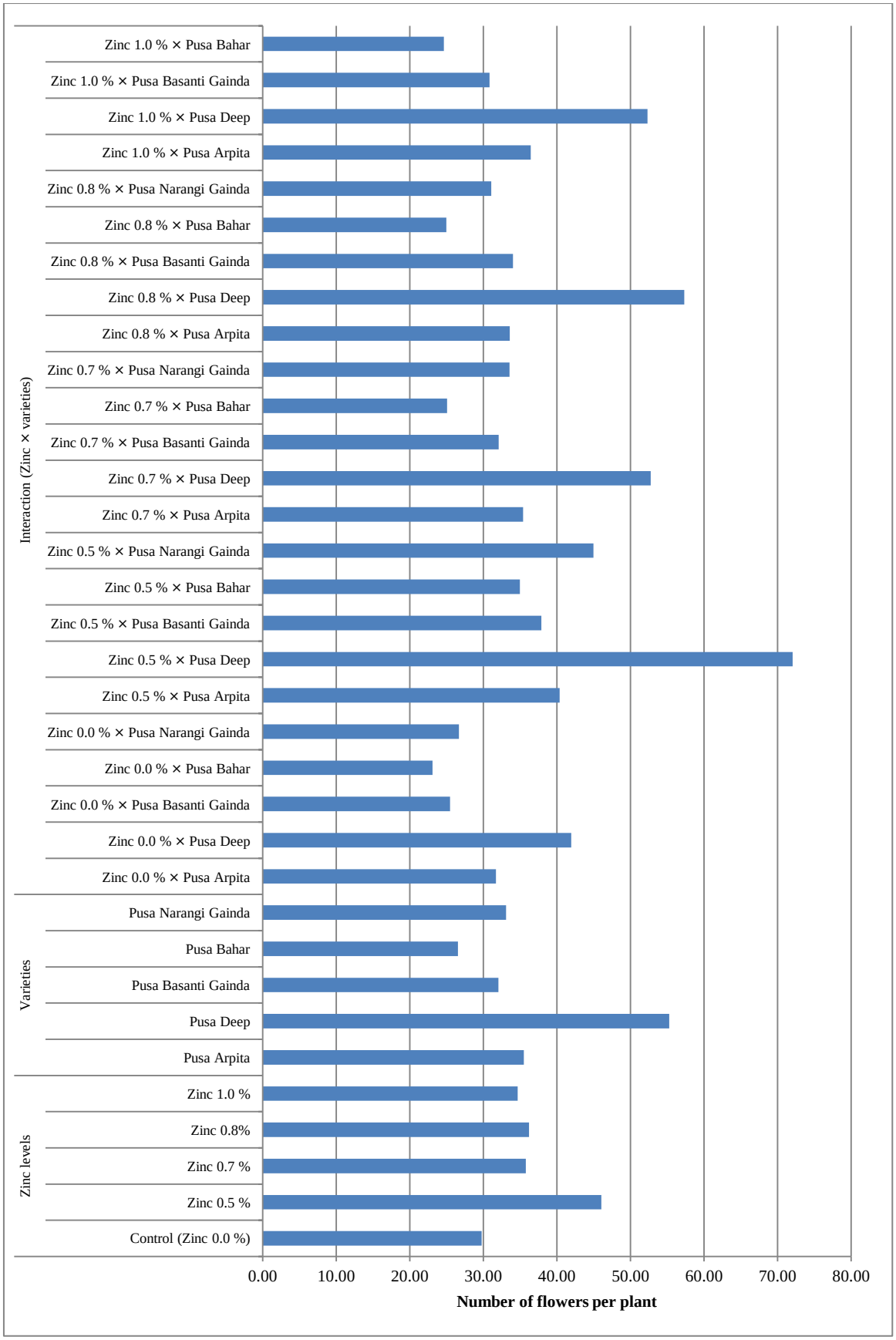


Figure 4.1.2.3. Effect of different level of zinc on number of flowers per plant in marigold

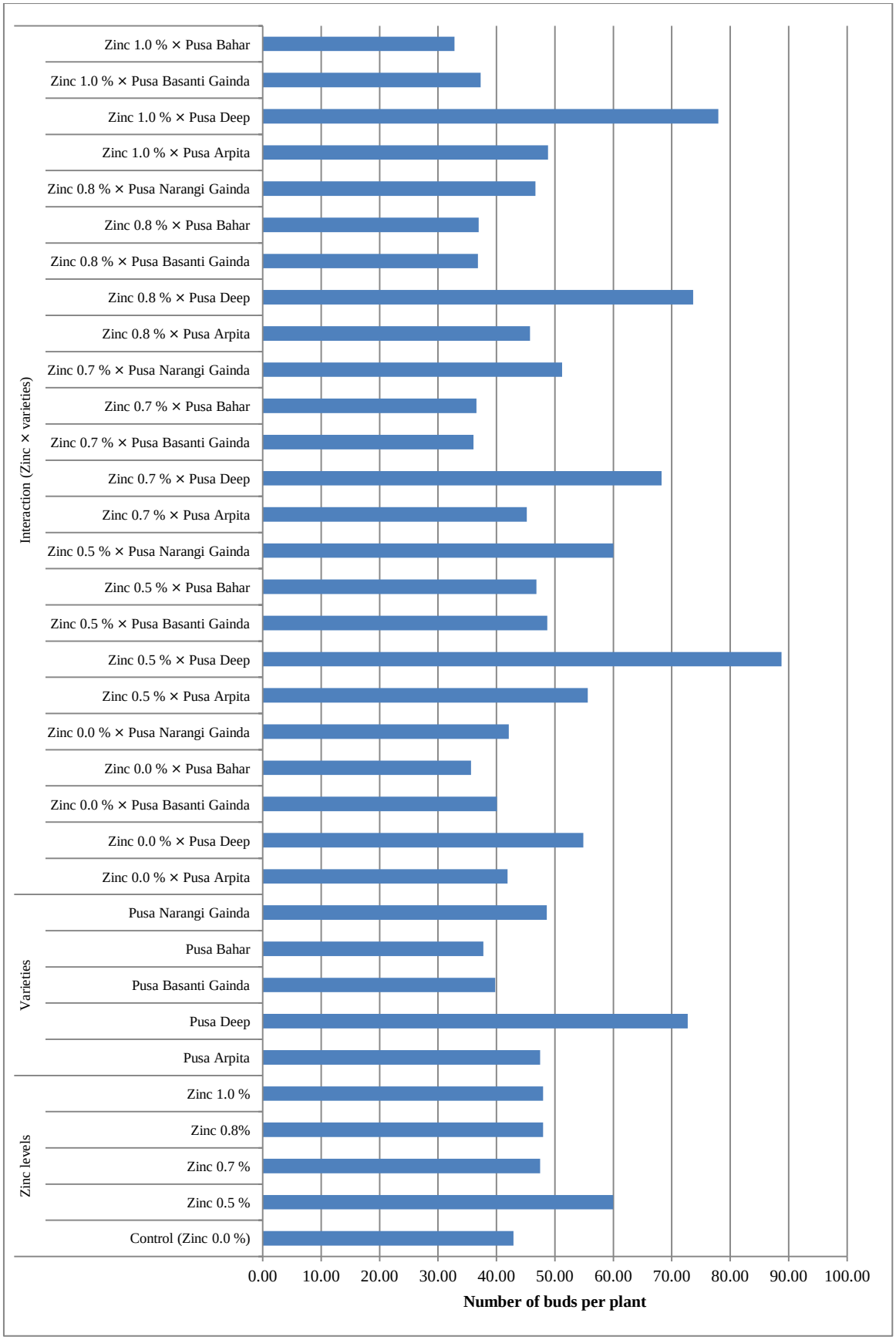


Figure 4.1.2.4 Effect of different level of zinc on number of buds per plant in marigold

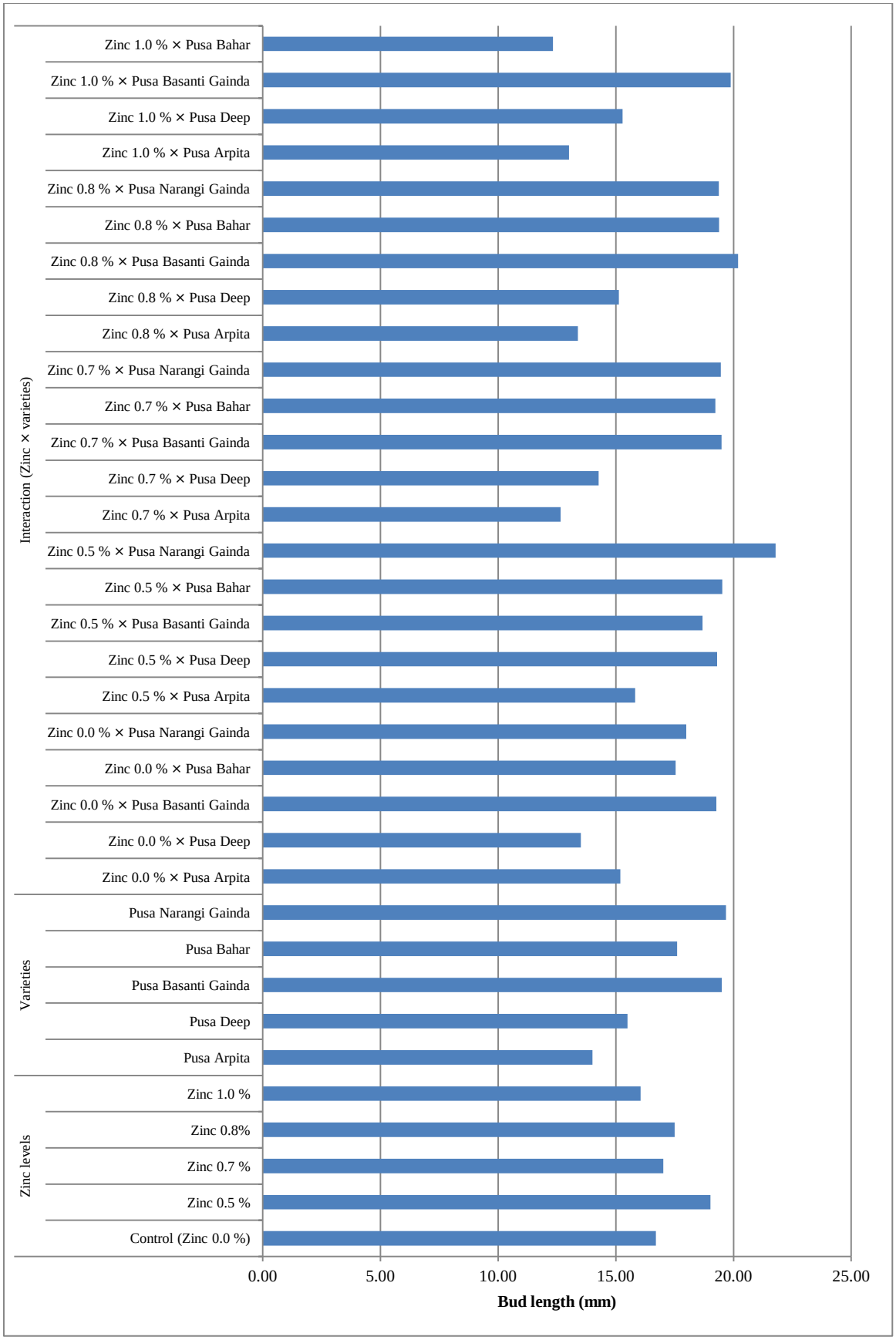


Figure 4.1.2.5. Effect of different level of zinc on bud length (mm) in marigold

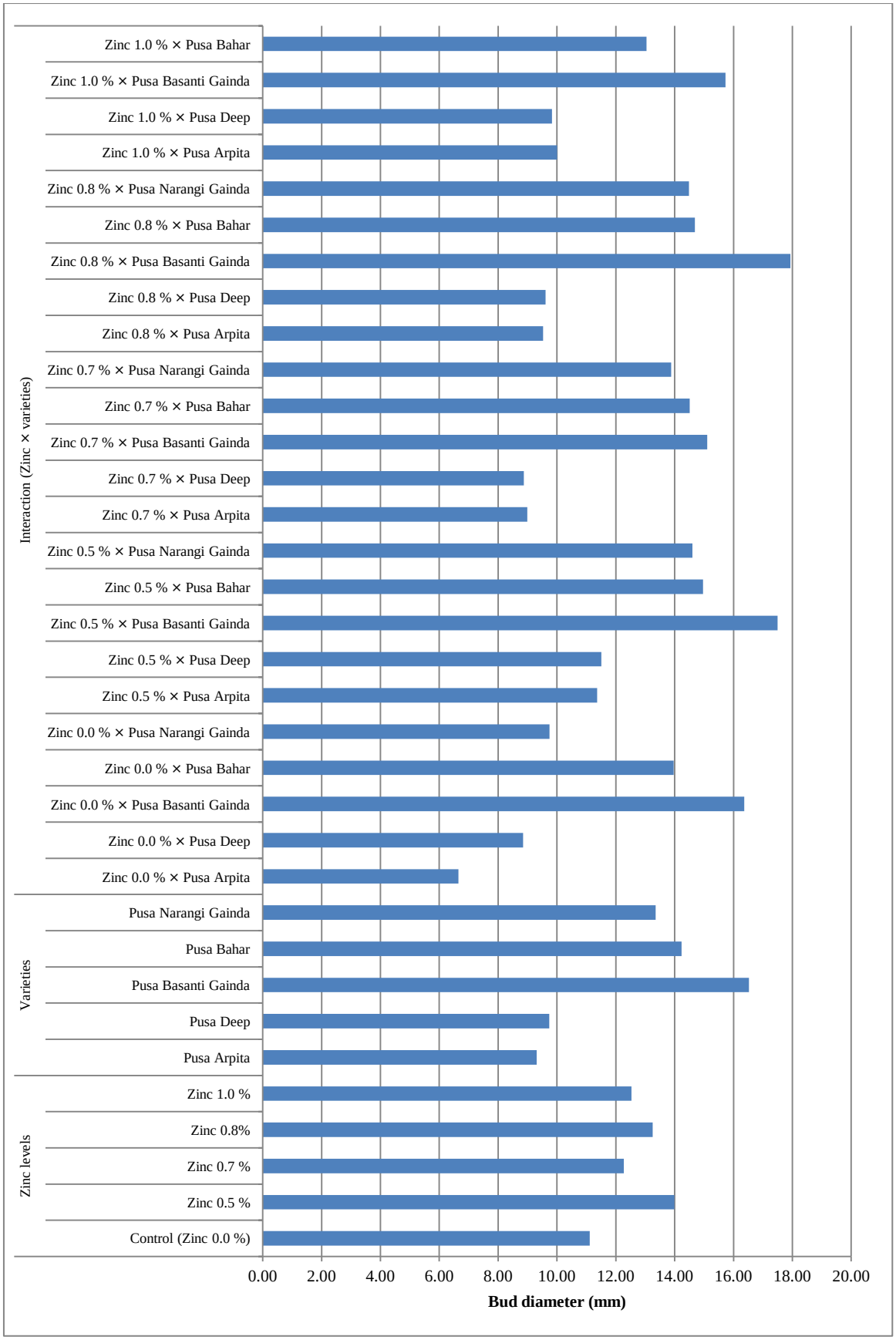


Figure 4.1.2.6. Effect of different level of zinc on bud diameter (mm) in marigold

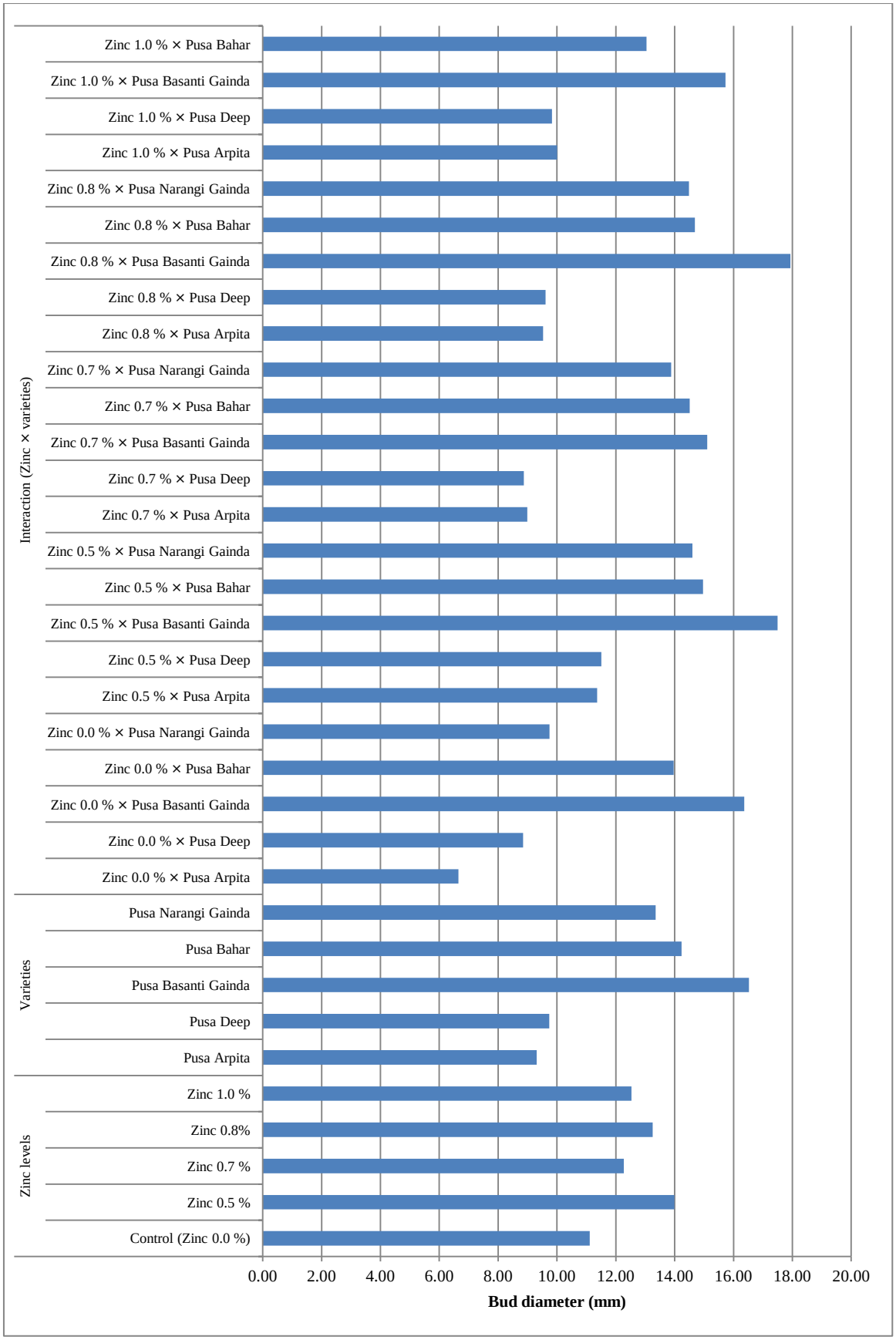


Figure 4.1.2.7. Effect of different level of zinc on flower diameter (mm) in marigold

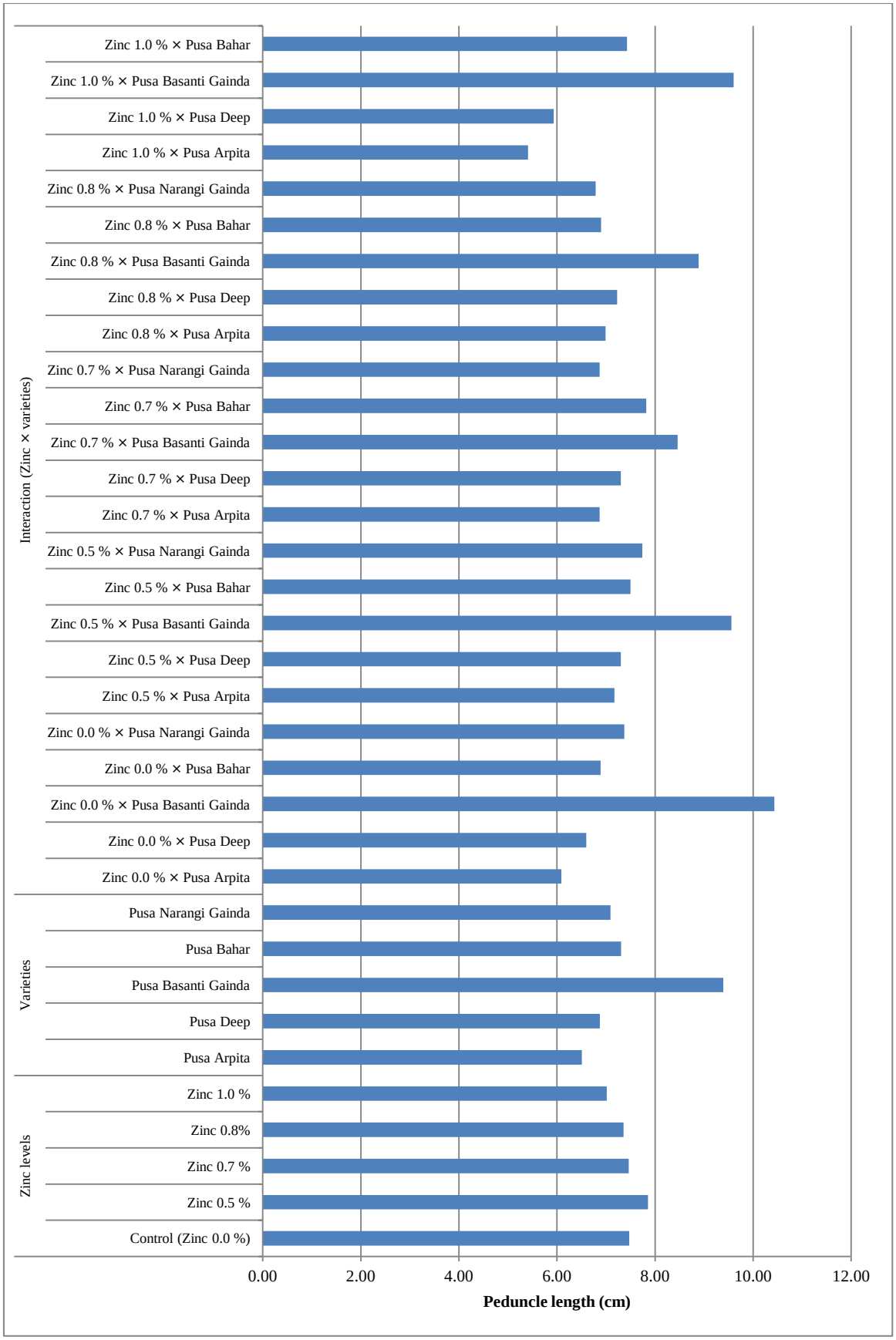


Figure 4.1.2.8. Effect of different level of zinc on peduncle length (cm) in marigold

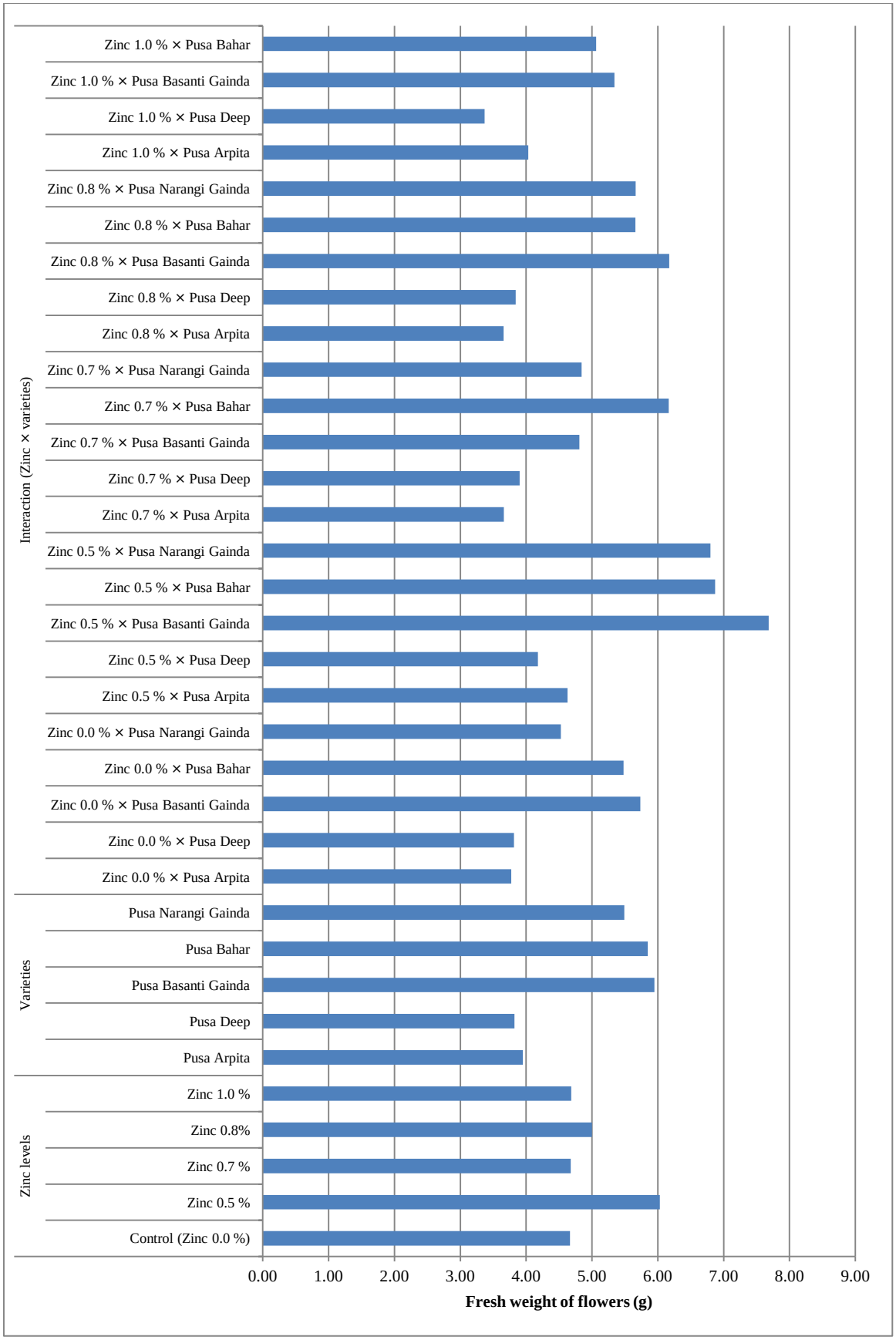


Figure 4.1.2.9. Effect of different level of zinc on fresh weight of flowers (g) in marigold

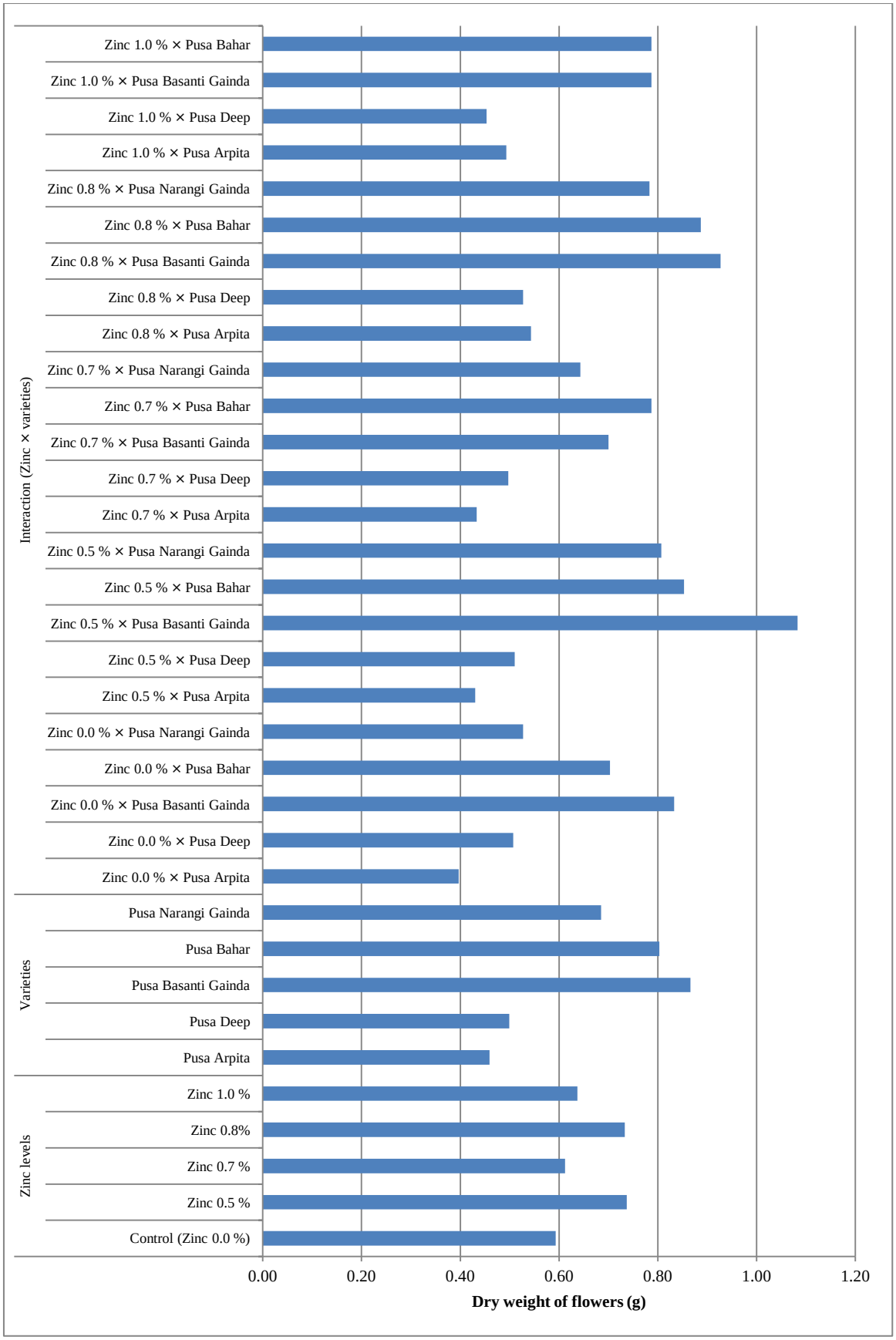


Figure 4.1.2.10 .Effect of different level of zinc on dry weight of flowers (g) in marigold

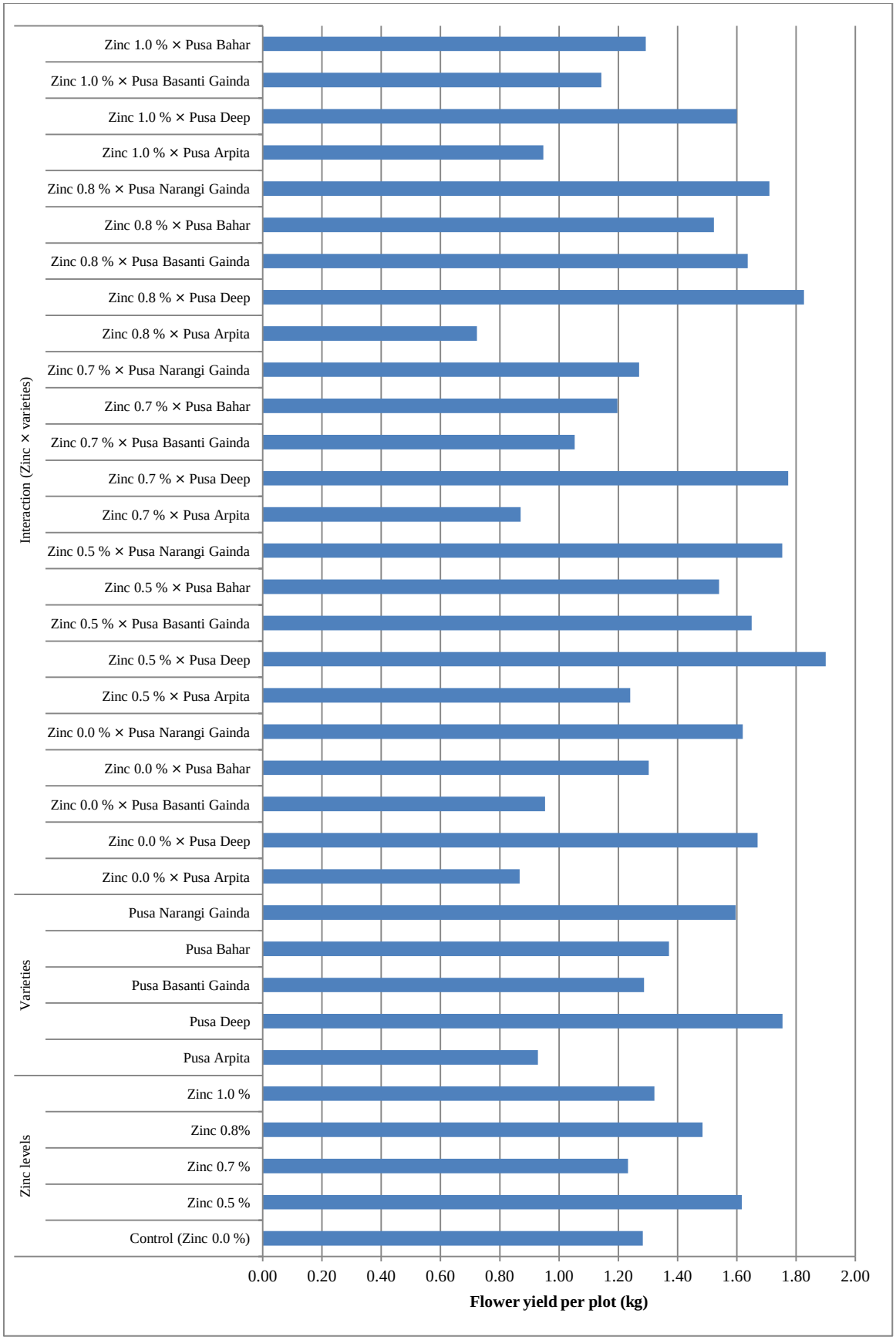


Figure 4.1.2.11. Effect of different level of zinc on flower yield per plot (kg) in marigold

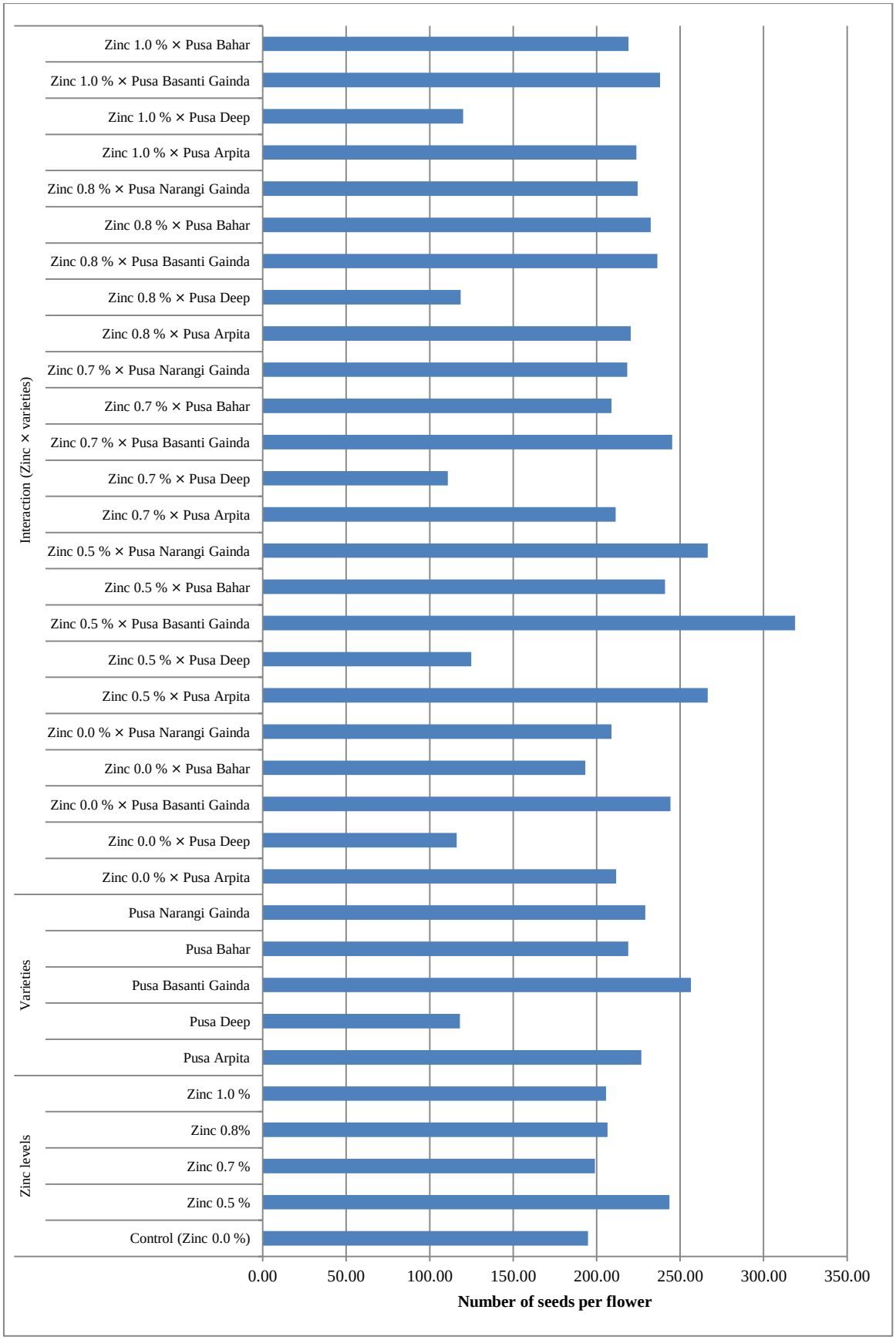


Figure 4.1.3.1. Effect of different level of zinc on number of seeds per flower in marigold

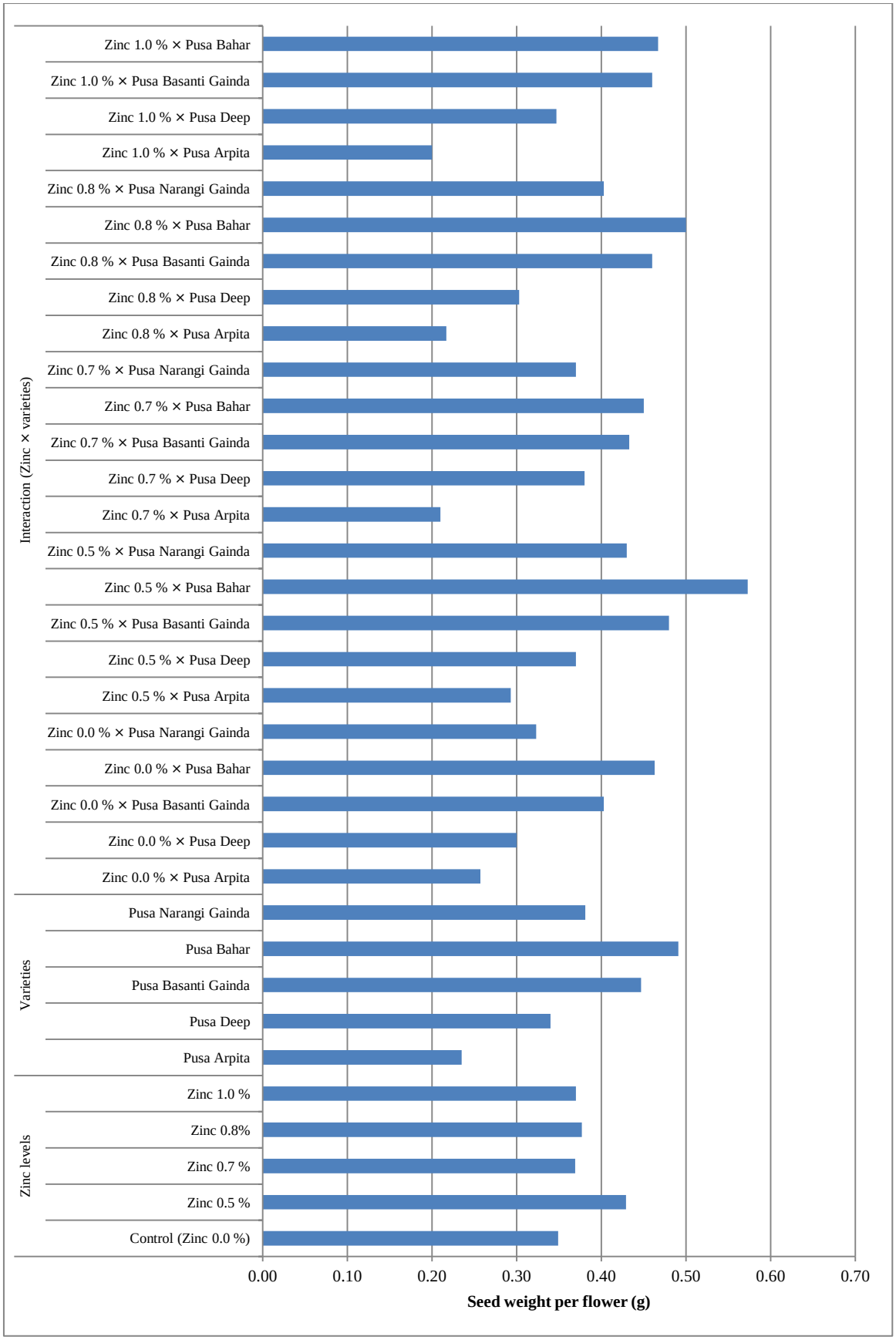


Figure 4.1.3.2. Effect of different level of zinc on seed weight per flower (g) in marigold

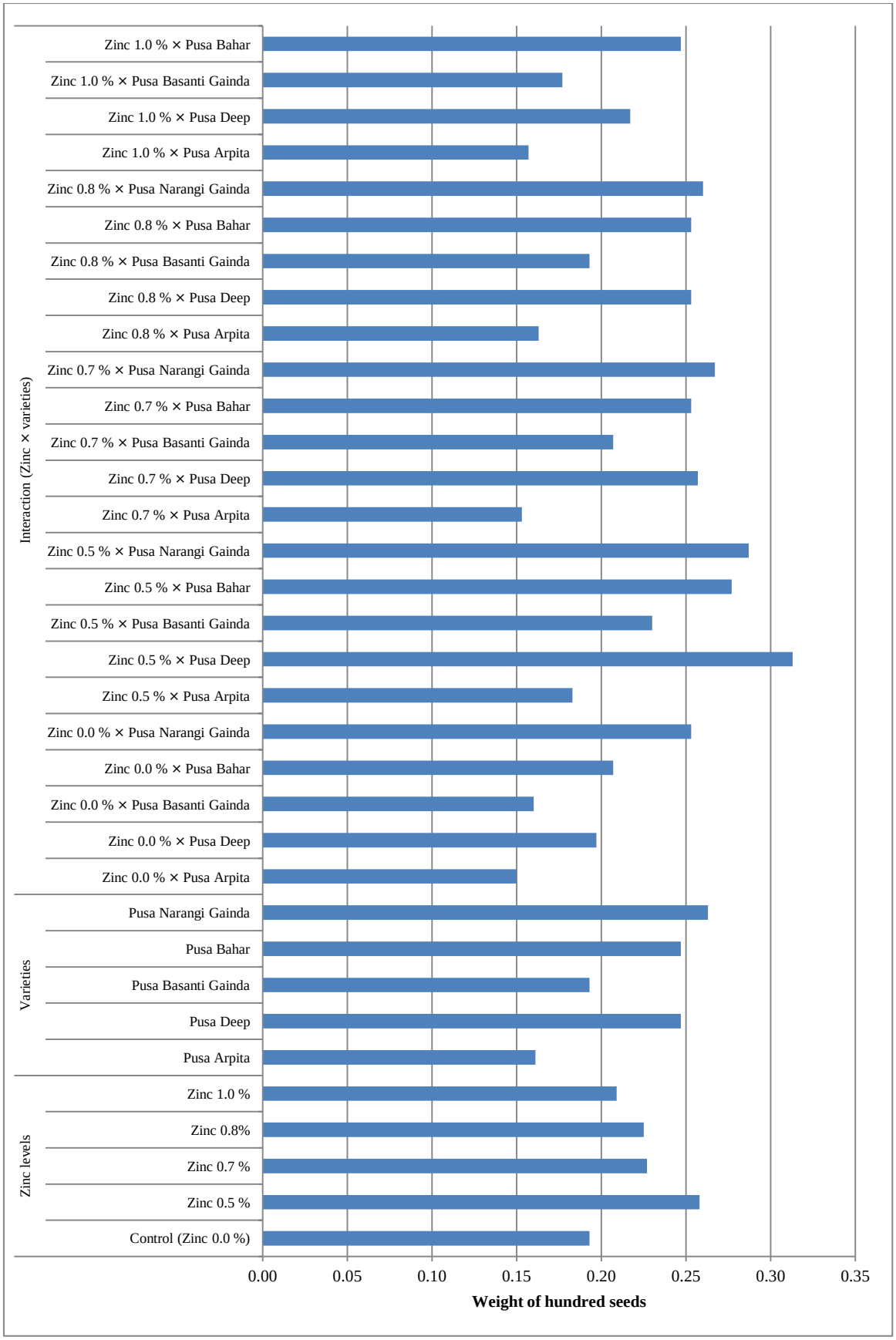


Figure 4.1.3.3. Effect of different level of zinc on weight of hundred seeds in marigold

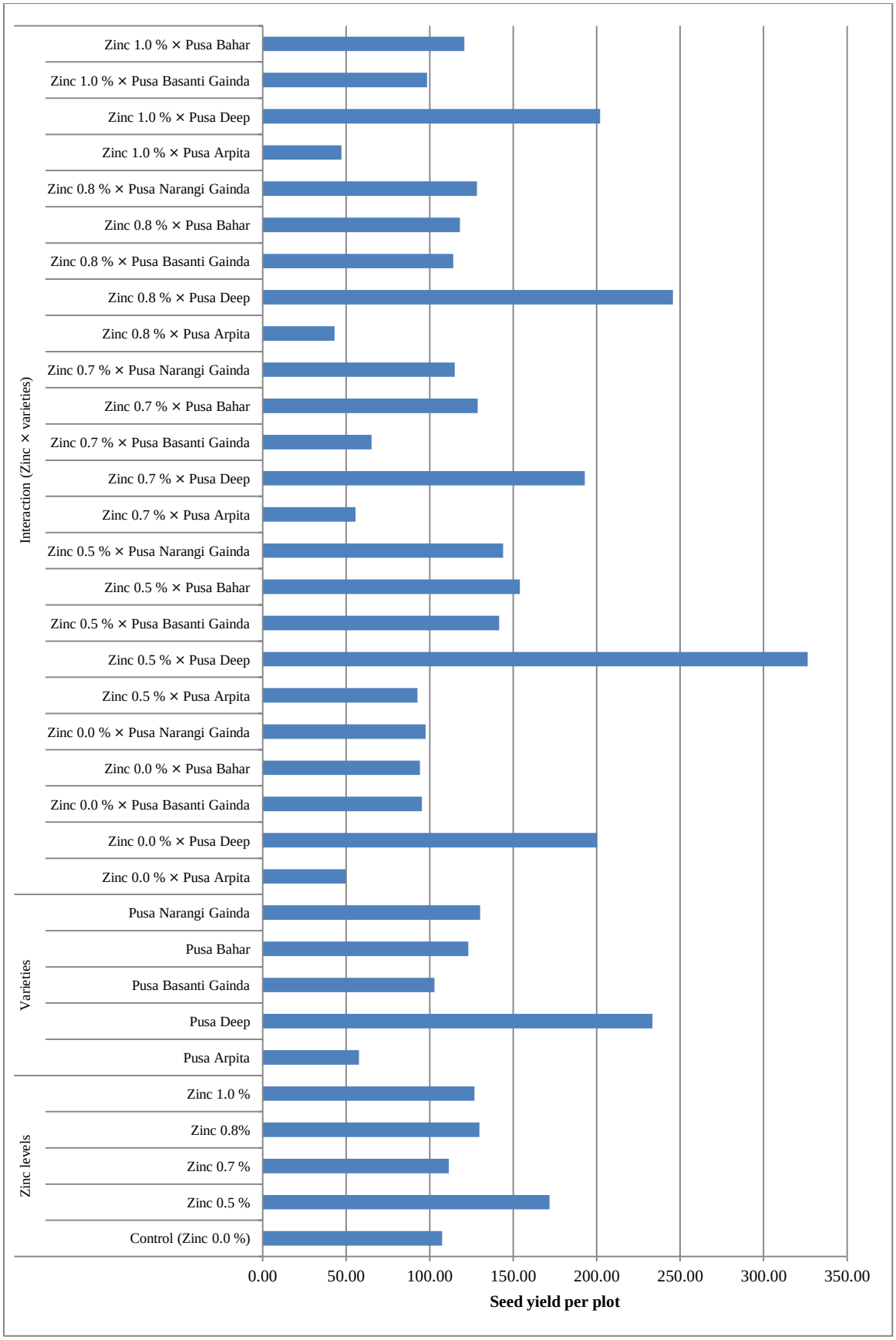


Figure 4.1.3.4. Effect of different level of zinc on seed yield per plot in marigold

Table 4.2.1.1: Effect of different level of pinching on plant height (cm) in marigold

Treatment	Plant height (cm)
P_0 (No Pinching)	47.77
P_1 (Single Pinching)	43.34
P_2 (Double Pinching)	40.09
P_3 (Third Pinching)	38.06
C.D. at 5%	1.97
Pusa Arpita	40.29
Pusa Deep	39.01
Pusa Basanti Gainda	50.30
Pusa Bahar	33.72
Pusa Narangi Gainda	48.25
C.D. at 5%	2.21
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	43.62
P_0 × Pusa Deep	41.00
P_0 × Pusa Basanti Gainda	59.80
P_0 × Pusa Bahar	39.37
P_0 × Pusa Narangi Gainda	55.03
P_1 × Pusa Arpita	42.37
P_1 × Pusa Deep	40.29
P_1 × Pusa Basanti Gainda	50.92
P_1 × Pusa Bahar	34.15
P_1 × Pusa Narangi Gainda	48.97
P_2 × Pusa Arpita	38.93
P_2 × Pusa Deep	38.07
P_2 × Pusa Basanti Gainda	46.20
P_2 × Pusa Bahar	31.96
P_2 × Pusa Narangi Gainda	45.29
P_3 × Pusa Arpita	36.23
P_3 × Pusa Deep	36.68
P_3 × Pusa Basanti Gainda	44.27
P_3 × Pusa Bahar	29.39
P_3 × Pusa Narangi Gainda	43.72
C.D. at 5%	N/A

Table 4.2.1.2: Effect of different level of pinching on stem diameter (cm) in marigold

Treatment	Stem diameter (cm)
P_0 (No Pinching)	10.87
P_1 (Single Pinching)	11.54
P_2 (Double Pinching)	13.42
P_3 (Third Pinching)	12.39
C.D. at 5%	0.62
Pusa Arpita	11.47
Pusa Deep	11.65
Pusa Basanti Gainda	13.73
Pusa Bahar	11.16
Pusa Narangi Gainda	12.26
C.D. at 5%	0.69
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	9.43
P_0 × Pusa Deep	9.56
P_0 × Pusa Basanti Gainda	13.14
P_0 × Pusa Bahar	10.68
P_0 × Pusa Narangi Gainda	11.51
P_1 × Pusa Arpita	11.19
P_1 × Pusa Deep	11.49
P_1 × Pusa Basanti Gainda	12.73
P_1 × Pusa Bahar	10.90
P_1 × Pusa Narangi Gainda	11.39
P_2 × Pusa Arpita	13.05
P_2 × Pusa Deep	13.48
P_2 × Pusa Basanti Gainda	15.10
P_2 × Pusa Bahar	11.99
P_2 × Pusa Narangi Gainda	13.48
P_3 × Pusa Arpita	12.22
P_3 × Pusa Deep	12.08
P_3 × Pusa Basanti Gainda	13.94
P_3 × Pusa Bahar	11.05
P_3 × Pusa Narangi Gainda	12.63
C.D. at 5%	NS

Table 4.2.1.3: Effect of different level of pinching on plant spread (cm) in marigold

Treatment	Plant spread (cm)
P_0 (No Pinching)	36.13
P_1 (Single Pinching)	42.92
P_2 (Double Pinching)	48.62
P_3 (Third Pinching)	52.79
C.D. at 5%	2.62
Pusa Arpita	46.27
Pusa Deep	46.12
Pusa Basanti Gainda	47.81
Pusa Bahar	33.94
Pusa Narangi Gainda	51.43
C.D. at 5%	2.93
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	38.13
P_0 × Pusa Deep	35.23
P_0 × Pusa Basanti Gainda	37.92
P_0 × Pusa Bahar	29.77
P_0 × Pusa Narangi Gainda	39.60
P_1 × Pusa Arpita	39.37
P_1 × Pusa Deep	43.85
P_1 × Pusa Basanti Gainda	45.08
P_1 × Pusa Bahar	34.33
P_1 × Pusa Narangi Gainda	51.96
P_2 × Pusa Arpita	48.44
P_2 × Pusa Deep	51.06
P_2 × Pusa Basanti Gainda	52.91
P_2 × Pusa Bahar	36.74
P_2 × Pusa Narangi Gainda	53.92
P_3 × Pusa Arpita	59.14
P_3 × Pusa Deep	54.31
P_3 × Pusa Basanti Gainda	55.33
P_3 × Pusa Bahar	34.92
P_3 × Pusa Narangi Gainda	60.23
C.D. at 5%	5.86

Table 4.2.1.4: Effect of different level of pinching on number of leaves in marigold

Treatment	Number of leaves
P_0 (No Pinching)	97.43
P_1 (Single Pinching)	196.37
P_2 (Double Pinching)	249.36
P_3 (Third Pinching)	266.76
C.D. at 5%	12.91
Pusa Arpita	207.70
Pusa Deep	317.34
Pusa Basanti Gainda	165.86
Pusa Bahar	119.48
Pusa Narangi Gainda	202.02
C.D. at 5%	14.44
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	76.30
P_0 × Pusa Deep	133.33
P_0 × Pusa Basanti Gainda	76.67
P_0 × Pusa Bahar	64.53
P_0 × Pusa Narangi Gainda	136.33
P_1 × Pusa Arpita	208.23
P_1 × Pusa Deep	302.04
P_1 × Pusa Basanti Gainda	156.90
P_1 × Pusa Bahar	127.35
P_1 × Pusa Narangi Gainda	187.31
P_2 × Pusa Arpita	266.78
P_2 × Pusa Deep	399.72
P_2 × Pusa Basanti Gainda	199.21
P_2 × Pusa Bahar	148.40
P_2 × Pusa Narangi Gainda	232.69
P_3 × Pusa Arpita	279.50
P_3 × Pusa Deep	434.29
P_3 × Pusa Basanti Gainda	230.65
P_3 × Pusa Bahar	137.61
P_3 × Pusa Narangi Gainda	251.73
C.D. at 5%	28.87

Table 4.2.1.5: Effect of different level of pinching on leaf length (cm) in marigold

Treatment	Leaf length(cm)
P_0 (No Pinching)	20.59
P_1 (Single Pinching)	16.14
P_2 (Double Pinching)	14.66
P_3 (Third Pinching)	13.76
C.D. at 5%	0.67
Pusa Arpita	20.39
Pusa Deep	20.80
Pusa Basanti Gainda	16.79
Pusa Bahar	11.18
Pusa Narangi Gainda	12.28
C.D. at 5%	0.75
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	22.26
P_0 × Pusa Deep	24.64
P_0 × Pusa Basanti Gainda	20.62
P_0 × Pusa Bahar	17.81
P_0 × Pusa Narangi Gainda	17.63
P_1 × Pusa Arpita	21.79
P_1 × Pusa Deep	20.62
P_1 × Pusa Basanti Gainda	16.56
P_1 × Pusa Bahar	10.30
P_1 × Pusa Narangi Gainda	11.43
P_2 × Pusa Arpita	19.46
P_2 × Pusa Deep	19.33
P_2 × Pusa Basanti Gainda	15.29
P_2 × Pusa Bahar	9.07
P_2 × Pusa Narangi Gainda	10.13
P_3 × Pusa Arpita	18.06
P_3 × Pusa Deep	18.61
P_3 × Pusa Basanti Gainda	14.70
P_3 × Pusa Bahar	7.53
P_3 × Pusa Narangi Gainda	9.90
C.D. at 5%	1.49

Table 4.2.1.6: Effect of different level of pinching on leaf width (cm) in marigold

Treatment	Leaf width (cm)
P_0 (No Pinching)	10.53
P_1 (Single Pinching)	9.00
P_2 (Double Pinching)	8.27
P_3 (Third Pinching)	8.03
C.D. at 5%	0.31
Pusa Arpita	10.27
Pusa Deep	10.45
Pusa Basanti Gainda	9.00
Pusa Bahar	6.58
Pusa Narangi Gainda	8.49
C.D. at 5%	0.35
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	10.93
P_0 × Pusa Deep	12.15
P_0 × Pusa Basanti Gainda	11.02
P_0 × Pusa Bahar	9.66
P_0 × Pusa Narangi Gainda	8.89
P_1 × Pusa Arpita	10.87
P_1 × Pusa Deep	10.67
P_1 × Pusa Basanti Gainda	8.67
P_1 × Pusa Bahar	6.27
P_1 × Pusa Narangi Gainda	8.53
P_2 × Pusa Arpita	9.87
P_2 × Pusa Deep	9.63
P_2 × Pusa Basanti Gainda	8.20
P_2 × Pusa Bahar	5.27
P_2 × Pusa Narangi Gainda	8.40
P_3 × Pusa Arpita	9.40
P_3 × Pusa Deep	9.37
P_3 × Pusa Basanti Gainda	8.10
P_3 × Pusa Bahar	5.13
P_3 × Pusa Narangi Gainda	8.13
C.D. at 5%	0.70

Table 4.2.1.7: Effect of different level of pinching on number of primary branch in marigold

Treatment	Number of primary branch
P_0 (No Pinching)	8.50
P_1 (Single Pinching)	12.22
P_2 (Double Pinching)	19.75
P_3 (Third Pinching)	19.30
C.D. at 5%	0.98
Pusa Arpita	16.97
Pusa Deep	19.90
Pusa Basanti Gainda	12.30
Pusa Bahar	11.51
Pusa Narangi Gainda	14.04
C.D. at 5%	1.10
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	8.17
P_0 × Pusa Deep	9.33
P_0 × Pusa Basanti Gainda	8.00
P_0 × Pusa Bahar	7.33
P_0 × Pusa Narangi Gainda	9.67
P_1 × Pusa Arpita	14.80
P_1 × Pusa Deep	16.10
P_1 × Pusa Basanti Gainda	12.33
P_1 × Pusa Bahar	7.77
P_1 × Pusa Narangi Gainda	10.10
P_2 × Pusa Arpita	22.67
P_2 × Pusa Deep	27.87
P_2 × Pusa Basanti Gainda	13.77
P_2 × Pusa Bahar	16.23
P_2 × Pusa Narangi Gainda	18.23
P_3 × Pusa Arpita	22.23
P_3 × Pusa Deep	26.30
P_3 × Pusa Basanti Gainda	15.10
P_3 × Pusa Bahar	14.70
P_3 × Pusa Narangi Gainda	18.17
C.D. at 5%	2.20

Table 4.2.1.8: Effect of different level of pinching on primary branch length (cm) in marigold

Treatment	Primary branch length (cm)
P_0 (No Pinching)	24.49
P_1 (Single Pinching)	21.49
P_2 (Double Pinching)	18.19
P_3 (Third Pinching)	17.42
C.D. at 5%	0.77
Pusa Arpita	22.66
Pusa Deep	21.97
Pusa Basanti Gainda	21.08
Pusa Bahar	16.49
Pusa Narangi Gainda	19.80
C.D. at 5%	0.86
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	28.83
P_0 × Pusa Deep	25.84
P_0 × Pusa Basanti Gainda	26.07
P_0 × Pusa Bahar	19.60
P_0 × Pusa Narangi Gainda	22.10
P_1 × Pusa Arpita	24.53
P_1 × Pusa Deep	24.61
P_1 × Pusa Basanti Gainda	22.27
P_1 × Pusa Bahar	16.77
P_1 × Pusa Narangi Gainda	19.27
P_2 × Pusa Arpita	19.40
P_2 × Pusa Deep	18.98
P_2 × Pusa Basanti Gainda	18.47
P_2 × Pusa Bahar	15.21
P_2 × Pusa Narangi Gainda	18.91
P_3 × Pusa Arpita	17.87
P_3 × Pusa Deep	18.43
P_3 × Pusa Basanti Gainda	17.50
P_3 × Pusa Bahar	14.37
P_3 × Pusa Narangi Gainda	18.93
C.D. at 5%	1.72

Table 4.2.1.9: Effect of different level of pinching on number of secondary branches in marigold

Treatment	No. of secondary branches
P_0 (No Pinching)	5.53
P_1 (Single Pinching)	17.76
P_2 (Double Pinching)	27.20
P_3 (Third Pinching)	29.70
C.D. at 5%	1.51
Pusa Arpita	24.47
Pusa Deep	28.78
Pusa Basanti Gainda	16.55
Pusa Bahar	11.93
Pusa Narangi Gainda	18.51
C.D. at 5%	1.69
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	4.67
P_0 × Pusa Deep	6.00
P_0 × Pusa Basanti Gainda	4.33
P_0 × Pusa Bahar	5.67
P_0 × Pusa Narangi Gainda	7.00
P_1 × Pusa Arpita	24.00
P_1 × Pusa Deep	27.55
P_1 × Pusa Basanti Gainda	16.99
P_1 × Pusa Bahar	11.07
P_1 × Pusa Narangi Gainda	9.21
P_2 × Pusa Arpita	32.66
P_2 × Pusa Deep	38.55
P_2 × Pusa Basanti Gainda	21.22
P_2 × Pusa Bahar	16.89
P_2 × Pusa Narangi Gainda	26.67
P_3 × Pusa Arpita	36.55
P_3 × Pusa Deep	43.00
P_3 × Pusa Basanti Gainda	23.66
P_3 × Pusa Bahar	14.11
P_3 × Pusa Narangi Gainda	31.17
C.D. at 5%	3.37

Table 4.2.1.10: Effect of different level of pinching on secondary branch length in marigold

Treatment	Secondary branch Length
P_0 (No Pinching)	13.73
P_1 (Single Pinching)	14.33
P_2 (Double Pinching)	20.23
P_3 (Third Pinching)	10.65
C.D. at 5%	0.71
Pusa Arpita	16.63
Pusa Deep	14.83
Pusa Basanti Gainda	17.76
Pusa Bahar	8.81
Pusa Narangi Gainda	15.63
C.D. at 5%	0.79
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	14.10
P_0 × Pusa Deep	14.60
P_0 × Pusa Basanti Gainda	18.27
P_0 × Pusa Bahar	6.03
P_0 × Pusa Narangi Gainda	15.67
P_1 × Pusa Arpita	13.99
P_1 × Pusa Deep	15.38
P_1 × Pusa Basanti Gainda	15.84
P_1 × Pusa Bahar	12.49
P_1 × Pusa Narangi Gainda	13.95
P_2 × Pusa Arpita	25.85
P_2 × Pusa Deep	19.05
P_2 × Pusa Basanti Gainda	27.06
P_2 × Pusa Bahar	9.66
P_2 × Pusa Narangi Gainda	19.51
P_3 × Pusa Arpita	12.59
P_3 × Pusa Deep	10.29
P_3 × Pusa Basanti Gainda	9.88
P_3 × Pusa Bahar	7.07
P_3 × Pusa Narangi Gainda	13.41
C.D. at 5%	1.58

Table 4.2.2.1: Effect of different level of pinching on number of flowers per plant in marigold

Treatment	No. of flower/Plant
P_0 (No Pinching)	35.19
P_1 (Single Pinching)	59.53
P_2 (Double Pinching)	75.70
P_3 (Third Pinching)	64.50
C.D. at 5%	4.60
Pusa Arpita	44.78
Pusa Deep	163.10
Pusa Basanti Gainda	28.30
Pusa Bahar	18.88
Pusa Narangi Gainda	38.60
C.D. at 5%	5.15
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	29.59
P_0 × Pusa Deep	74.58
P_0 × Pusa Basanti Gainda	23.63
P_0 × Pusa Bahar	18.18
P_0 × Pusa Narangi Gainda	29.97
P_1 × Pusa Arpita	47.33
P_1 × Pusa Deep	177.65
P_1 × Pusa Basanti Gainda	24.33
P_1 × Pusa Bahar	13.00
P_1 × Pusa Narangi Gainda	35.32
P_2 × Pusa Arpita	61.33
P_2 × Pusa Deep	206.95
P_2 × Pusa Basanti Gainda	36.11
P_2 × Pusa Bahar	25.66
P_2 × Pusa Narangi Gainda	48.44
P_3 × Pusa Arpita	40.89
P_3 × Pusa Deep	193.20
P_3 × Pusa Basanti Gainda	29.11
P_3 × Pusa Bahar	18.66
P_3 × Pusa Narangi Gainda	40.66
C.D. at 5%	10.29

Table 4.2.2.2: Effect of different level of pinching on number of buds in marigold

Treatment	No. of Buds/Plant
P_0 (No Pinching)	45.38
P_1 (Single Pinching)	68.82
P_2 (Double Pinching)	84.53
P_3 (Third Pinching)	74.31
C.D. at 5%	6.60
Pusa Arpita	54.38
Pusa Deep	178.41
Pusa Basanti Gainda	35.73
Pusa Bahar	24.38
Pusa Narangi Gainda	48.38
C.D. at 5%	7.38
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	41.86
P_0 × Pusa Deep	97.67
P_0 × Pusa Basanti Gainda	24.83
P_0 × Pusa Bahar	22.77
P_0 × Pusa Narangi Gainda	39.75
P_1 × Pusa Arpita	51.00
P_1 × Pusa Deep	191.66
P_1 × Pusa Basanti Gainda	33.09
P_1 × Pusa Bahar	21.66
P_1 × Pusa Narangi Gainda	46.66
P_2 × Pusa Arpita	74.00
P_2 × Pusa Deep	219.33
P_2 × Pusa Basanti Gainda	47.00
P_2 × Pusa Bahar	24.55
P_2 × Pusa Narangi Gainda	57.77
P_3 × Pusa Arpita	50.66
P_3 × Pusa Deep	205.00
P_3 × Pusa Basanti Gainda	38.00
P_3 × Pusa Bahar	28.55
P_3 × Pusa Narangi Gainda	49.33
C.D. at 5%	14.76

Table 4.2.2.3: Effect of different level of pinching on bud length (mm) in marigold

Treatment	Bud Length (mm)
P_0 (No Pinching)	15.50
P_1 (Single Pinching)	14.93
P_2 (Double Pinching)	12.78
P_3 (Third Pinching)	11.03
C.D. at 5%	0.50
Pusa Arpita	11.95
Pusa Deep	10.28
Pusa Basanti Gainda	16.14
Pusa Bahar	14.06
Pusa Narangi Gainda	15.36
C.D. at 5%	0.56
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	13.63
P_0 × Pusa Deep	11.71
P_0 × Pusa Basanti Gainda	18.26
P_0 × Pusa Bahar	15.99
P_0 × Pusa Narangi Gainda	17.89
P_1 × Pusa Arpita	13.31
P_1 × Pusa Deep	11.52
P_1 × Pusa Basanti Gainda	17.72
P_1 × Pusa Bahar	15.58
P_1 × Pusa Narangi Gainda	16.52
P_2 × Pusa Arpita	11.07
P_2 × Pusa Deep	9.51
P_2 × Pusa Basanti Gainda	15.49
P_2 × Pusa Bahar	13.35
P_2 × Pusa Narangi Gainda	14.46
P_3 × Pusa Arpita	9.79
P_3 × Pusa Deep	8.36
P_3 × Pusa Basanti Gainda	13.08
P_3 × Pusa Bahar	11.32
P_3 × Pusa Narangi Gainda	12.59
C.D. at 5%	N/A

Table 4.2.2.4: Effect of different level of pinching on bud diameter (mm) in marigold

Treatment	Bud diameter (mm)
P_0 (No Pinching)	11.09
P_1 (Single Pinching)	10.26
P_2 (Double Pinching)	8.21
P_3 (Third Pinching)	7.00
C.D. at 5%	0.57
Pusa Arpita	5.36
Pusa Deep	5.63
Pusa Basanti Gainda	13.44
Pusa Bahar	10.45
Pusa Narangi Gainda	10.82
C.D. at 5%	0.63
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	6.63
P_0 × Pusa Deep	7.21
P_0 × Pusa Basanti Gainda	15.39
P_0 × Pusa Bahar	12.46
P_0 × Pusa Narangi Gainda	13.78
P_1 × Pusa Arpita	6.46
P_1 × Pusa Deep	6.90
P_1 × Pusa Basanti Gainda	14.36
P_1 × Pusa Bahar	11.77
P_1 × Pusa Narangi Gainda	11.80
P_2 × Pusa Arpita	4.65
P_2 × Pusa Deep	4.80
P_2 × Pusa Basanti Gainda	12.79
P_2 × Pusa Bahar	9.31
P_2 × Pusa Narangi Gainda	9.48
P_3 × Pusa Arpita	3.68
P_3 × Pusa Deep	3.62
P_3 × Pusa Basanti Gainda	11.24
P_3 × Pusa Bahar	8.24
P_3 × Pusa Narangi Gainda	8.23
C.D. at 5%	N/A

Table 4.2.2.5: Effect of different level of pinching on flower diameter (cm) in marigold

Treatment	Flower diameter (cm)
P_0 (No Pinching)	52.89
P_1 (Single Pinching)	50.92
P_2 (Double Pinching)	48.96
P_3 (Third Pinching)	46.61
C.D. at 5%	1.18
Pusa Arpita	43.41
Pusa Deep	47.23
Pusa Basanti Gainda	61.38
Pusa Bahar	43.60
Pusa Narangi Gainda	53.60
C.D. at 5%	1.32
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	46.99
P_0 × Pusa Deep	51.50
P_0 × Pusa Basanti Gainda	63.44
P_0 × Pusa Bahar	46.16
P_0 × Pusa Narangi Gainda	56.36
P_1 × Pusa Arpita	44.80
P_1 × Pusa Deep	47.98
P_1 × Pusa Basanti Gainda	62.75
P_1 × Pusa Bahar	44.61
P_1 × Pusa Narangi Gainda	54.46
P_2 × Pusa Arpita	42.00
P_2 × Pusa Deep	45.79
P_2 × Pusa Basanti Gainda	60.82
P_2 × Pusa Bahar	43.39
P_2 × Pusa Narangi Gainda	52.79
P_3 × Pusa Arpita	39.86
P_3 × Pusa Deep	43.64
P_3 × Pusa Basanti Gainda	58.50
P_3 × Pusa Bahar	40.25
P_3 × Pusa Narangi Gainda	50.78
C.D. at 5%	N/A

Table 4.2.2.6. Effect of different level of pinching on peduncle length (cm) in marigold

Treatment	Peduncle length (cm)
P_0 (No Pinching)	6.02
P_1 (Single Pinching)	5.71
P_2 (Double Pinching)	5.07
P_3 (Third Pinching)	3.96
C.D. at 5%	0.28
Pusa Arpita	4.20
Pusa Deep	4.73
Pusa Basanti Gainda	7.11
Pusa Bahar	4.77
Pusa Narangi Gainda	5.14
C.D. at 5%	0.31
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	4.87
P_0 × Pusa Deep	5.72
P_0 × Pusa Basanti Gainda	8.40
P_0 × Pusa Bahar	5.33
P_0 × Pusa Narangi Gainda	5.80
P_1 × Pusa Arpita	4.45
P_1 × Pusa Deep	5.40
P_1 × Pusa Basanti Gainda	8.16
P_1 × Pusa Bahar	5.12
P_1 × Pusa Narangi Gainda	5.42
P_2 × Pusa Arpita	3.95
P_2 × Pusa Deep	4.26
P_2 × Pusa Basanti Gainda	7.59
P_2 × Pusa Bahar	4.43
P_2 × Pusa Narangi Gainda	5.10
P_3 × Pusa Arpita	3.52
P_3 × Pusa Deep	3.55
P_3 × Pusa Basanti Gainda	4.31
P_3 × Pusa Bahar	4.19
P_3 × Pusa Narangi Gainda	4.25
C.D. at 5%	0.62

Table 4.2.2.7: Effect of different level of pinching on fresh weight of flower (g) in marigold

Treatment	Fresh wt. of flower (g)
P_0 (No Pinching)	4.68
P_1 (Single Pinching)	4.48
P_2 (Double Pinching)	4.36
P_3 (Third Pinching)	3.96
C.D. at 5%	0.28
Pusa Arpita	3.49
Pusa Deep	3.54
Pusa Basanti Gainda	5.46
Pusa Bahar	5.01
Pusa Narangi Gainda	4.37
C.D. at 5%	0.31
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	3.92
P_0 × Pusa Deep	3.77
P_0 × Pusa Basanti Gainda	5.91
P_0 × Pusa Bahar	5.17
P_0 × Pusa Narangi Gainda	4.64
P_1 × Pusa Arpita	3.50
P_1 × Pusa Deep	3.65
P_1 × Pusa Basanti Gainda	5.57
P_1 × Pusa Bahar	5.29
P_1 × Pusa Narangi Gainda	4.38
P_2 × Pusa Arpita	3.36
P_2 × Pusa Deep	3.45
P_2 × Pusa Basanti Gainda	5.42
P_2 × Pusa Bahar	4.95
P_2 × Pusa Narangi Gainda	4.64
P_3 × Pusa Arpita	3.16
P_3 × Pusa Deep	3.28
P_3 × Pusa Basanti Gainda	4.92
P_3 × Pusa Bahar	4.64
P_3 × Pusa Narangi Gainda	3.80
C.D. at 5%	N/A

Table 4.2.2.8. Effect of different level of pinching on dry weight of flower (g) in marigold

Treatment	Dry wt of flower (g)
P_0 (No Pinching)	1.69
P_1 (Single Pinching)	1.59
P_2 (Double Pinching)	1.47
P_3 (Third Pinching)	1.45
C.D. at 5%	0.09
Pusa Arpita	1.29
Pusa Deep	1.42
Pusa Basanti Gainda	2.03
Pusa Bahar	1.68
Pusa Narangi Gainda	1.33
C.D. at 5%	0.10
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	1.44
P_0 × Pusa Deep	1.47
P_0 × Pusa Basanti Gainda	2.36
P_0 × Pusa Bahar	1.75
P_0 × Pusa Narangi Gainda	1.42
P_1 × Pusa Arpita	1.31
P_1 × Pusa Deep	1.43
P_1 × Pusa Basanti Gainda	2.20
P_1 × Pusa Bahar	1.69
P_1 × Pusa Narangi Gainda	1.34
P_2 × Pusa Arpita	1.23
P_2 × Pusa Deep	1.40
P_2 × Pusa Basanti Gainda	1.80
P_2 × Pusa Bahar	1.66
P_2 × Pusa Narangi Gainda	1.26
P_3 × Pusa Arpita	1.19
P_3 × Pusa Deep	1.37
P_3 × Pusa Basanti Gainda	1.78
P_3 × Pusa Bahar	1.61
P_3 × Pusa Narangi Gainda	1.30
C.D. at 5%	0.20

Table 4.2.2.9: Effect of different level of pinching on flower yield per plot (g) in marigold

Treatment	Flower yield per plot (g)
P_0 (No Pinching)	565.82
P_1 (Single Pinching)	702.82
P_2 (Double Pinching)	841.97
P_3 (Third Pinching)	685.65
C.D. at 5%	65.92
Pusa Arpita	466.65
Pusa Deep	1893.33
Pusa Basanti Gainda	422.09
Pusa Bahar	275.39
Pusa Narangi Gainda	437.86
C.D. at 5%	73.70
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	389.30
P_0 × Pusa Deep	1580.87
P_0 × Pusa Basanti Gainda	346.28
P_0 × Pusa Bahar	253.41
P_0 × Pusa Narangi Gainda	259.22
P_1 × Pusa Arpita	493.47
P_1 × Pusa Deep	1955.94
P_1 × Pusa Basanti Gainda	414.03
P_1 × Pusa Bahar	206.89
P_1 × Pusa Narangi Gainda	443.74
P_2 × Pusa Arpita	613.42
P_2 × Pusa Deep	2136.21
P_2 × Pusa Basanti Gainda	493.02
P_2 × Pusa Bahar	381.62
P_2 × Pusa Narangi Gainda	585.60
P_3 × Pusa Arpita	370.39
P_3 × Pusa Deep	1900.31
P_3 × Pusa Basanti Gainda	435.04
P_3 × Pusa Bahar	259.64
P_3 × Pusa Narangi Gainda	462.87
C.D. at 5%	147.39

Table 4.2.3.1. Effect of different level of pinching on number of seed per flower in marigold

Treatment	No. of seed/flower
P_0 (No Pinching)	218.47
P_1 (Single Pinching)	210.47
P_2 (Double Pinching)	206.39
P_3 (Third Pinching)	194.80
C.D. at 5%	5.92
Pusa Arpita	143.03
Pusa Deep	112.94
Pusa Basanti Gainda	269.42
Pusa Bahar	255.52
Pusa Narangi Gainda	256.76
C.D. at 5%	6.62
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	126.43
P_0 × Pusa Deep	116.20
P_0 × Pusa Basanti Gainda	286.10
P_0 × Pusa Bahar	282.63
P_0 × Pusa Narangi Gainda	280.97
P_1 × Pusa Arpita	118.53
P_1 × Pusa Deep	111.17
P_1 × Pusa Basanti Gainda	276.40
P_1 × Pusa Bahar	275.40
P_1 × Pusa Narangi Gainda	270.87
P_2 × Pusa Arpita	115.40
P_2 × Pusa Deep	108.27
P_2 × Pusa Basanti Gainda	271.00
P_2 × Pusa Bahar	270.87
P_2 × Pusa Narangi Gainda	266.40
P_3 × Pusa Arpita	211.73
P_3 × Pusa Deep	116.11
P_3 × Pusa Basanti Gainda	244.17
P_3 × Pusa Bahar	193.18
P_3 × Pusa Narangi Gainda	208.81
C.D. at 5%	13.25

Table 4.2.3.2. Effect of different level of pinching on weight of hundred seed in marigold

Treatment	Weight of hundred seed
P_0 (No Pinching)	0.19
P_1 (Single Pinching)	0.28
P_2 (Double Pinching)	0.24
P_3 (Third Pinching)	0.23
C.D. at 5%	0.01
Pusa Arpita	0.17
Pusa Deep	0.27
Pusa Basanti Gainda	0.23
Pusa Bahar	0.24
Pusa Narangi Gainda	0.27
C.D. at 5%	0.01
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	0.15
P_0 × Pusa Deep	0.20
P_0 × Pusa Basanti Gainda	0.16
P_0 × Pusa Bahar	0.21
P_0 × Pusa Narangi Gainda	0.25
P_1 × Pusa Arpita	0.22
P_1 × Pusa Deep	0.33
P_1 × Pusa Basanti Gainda	0.27
P_1 × Pusa Bahar	0.26
P_1 × Pusa Narangi Gainda	0.31
P_2 × Pusa Arpita	0.16
P_2 × Pusa Deep	0.28
P_2 × Pusa Basanti Gainda	0.26
P_2 × Pusa Bahar	0.24
P_2 × Pusa Narangi Gainda	0.27
P_3 × Pusa Arpita	0.16
P_3 × Pusa Deep	0.26
P_3 × Pusa Basanti Gainda	0.22
P_3 × Pusa Bahar	0.24
P_3 × Pusa Narangi Gainda	0.26
C.D. at 5%	0.02

Table 4.2.3.3. Effect of different level of pinching on weight of seed per flower (g) in marigold

Treatment	Wt. of seed/Flower (g)
P_0 (No Pinching)	0.29
P_1 (Single Pinching)	0.26
P_2 (Double Pinching)	0.23
P_3 (Third Pinching)	0.21
C.D. at 5%	0.01
Pusa Arpita	0.21
Pusa Deep	0.30
Pusa Basanti Gainda	0.23
Pusa Bahar	0.25
Pusa Narangi Gainda	0.26
C.D. at 5%	0.01
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	0.24
P_0 × Pusa Deep	0.35
P_0 × Pusa Basanti Gainda	0.25
P_0 × Pusa Bahar	0.29
P_0 × Pusa Narangi Gainda	0.29
P_1 × Pusa Arpita	0.23
P_1 × Pusa Deep	0.30
P_1 × Pusa Basanti Gainda	0.24
P_1 × Pusa Bahar	0.25
P_1 × Pusa Narangi Gainda	0.27
P_2 × Pusa Arpita	0.18
P_2 × Pusa Deep	0.28
P_2 × Pusa Basanti Gainda	0.22
P_2 × Pusa Bahar	0.23
P_2 × Pusa Narangi Gainda	0.25
P_3 × Pusa Arpita	0.18
P_3 × Pusa Deep	0.25
P_3 × Pusa Basanti Gainda	0.20
P_3 × Pusa Bahar	0.21
P_3 × Pusa Narangi Gainda	0.23
C.D. at 5%	N/A

Table 4.2.3.4: Effect of different level of pinching on seed yield per plot (g) in marigold

Treatment	Seed yield/Plot (g)
P_0 (No Pinching)	39.74
P_1 (Single Pinching)	50.62
P_2 (Double Pinching)	57.44
P_3 (Third Pinching)	44.75
C.D. at 5%	3.35
Pusa Arpita	28.19
Pusa Deep	151.53
Pusa Basanti Gainda	18.92
Pusa Bahar	13.53
Pusa Narangi Gainda	28.51
C.D. at 5%	3.74
Interaction (Pinching × Varieties)	
P_0 × Pusa Arpita	24.99
P_0 × Pusa Deep	125.29
P_0 × Pusa Basanti Gainda	14.88
P_0 × Pusa Bahar	11.35
P_0 × Pusa Narangi Gainda	22.17
P_1 × Pusa Arpita	32.21
P_1 × Pusa Deep	160.69
P_1 × Pusa Basanti Gainda	19.30
P_1 × Pusa Bahar	13.50
P_1 × Pusa Narangi Gainda	27.37
P_2 × Pusa Arpita	33.82
P_2 × Pusa Deep	175.54
P_2 × Pusa Basanti Gainda	24.38
P_2 × Pusa Bahar	17.49
P_2 × Pusa Narangi Gainda	35.97
P_3 × Pusa Arpita	21.73
P_3 × Pusa Deep	144.59
P_3 × Pusa Basanti Gainda	17.12
P_3 × Pusa Bahar	11.79
P_3 × Pusa Narangi Gainda	28.54
C.D. at 5%	7.48

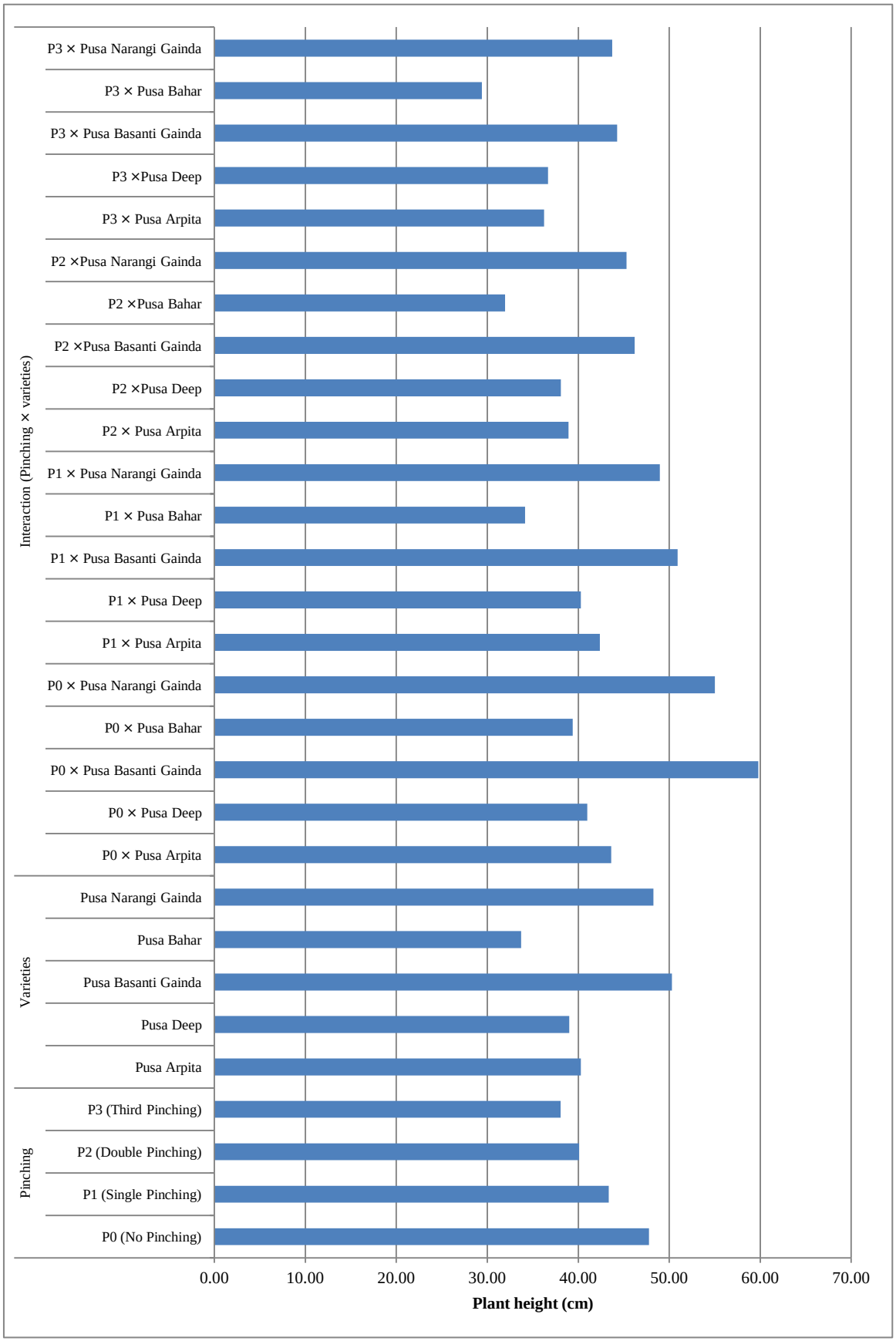


Figure 4.2.1.1. Effect of different level of pinching on plant height (cm) in marigold

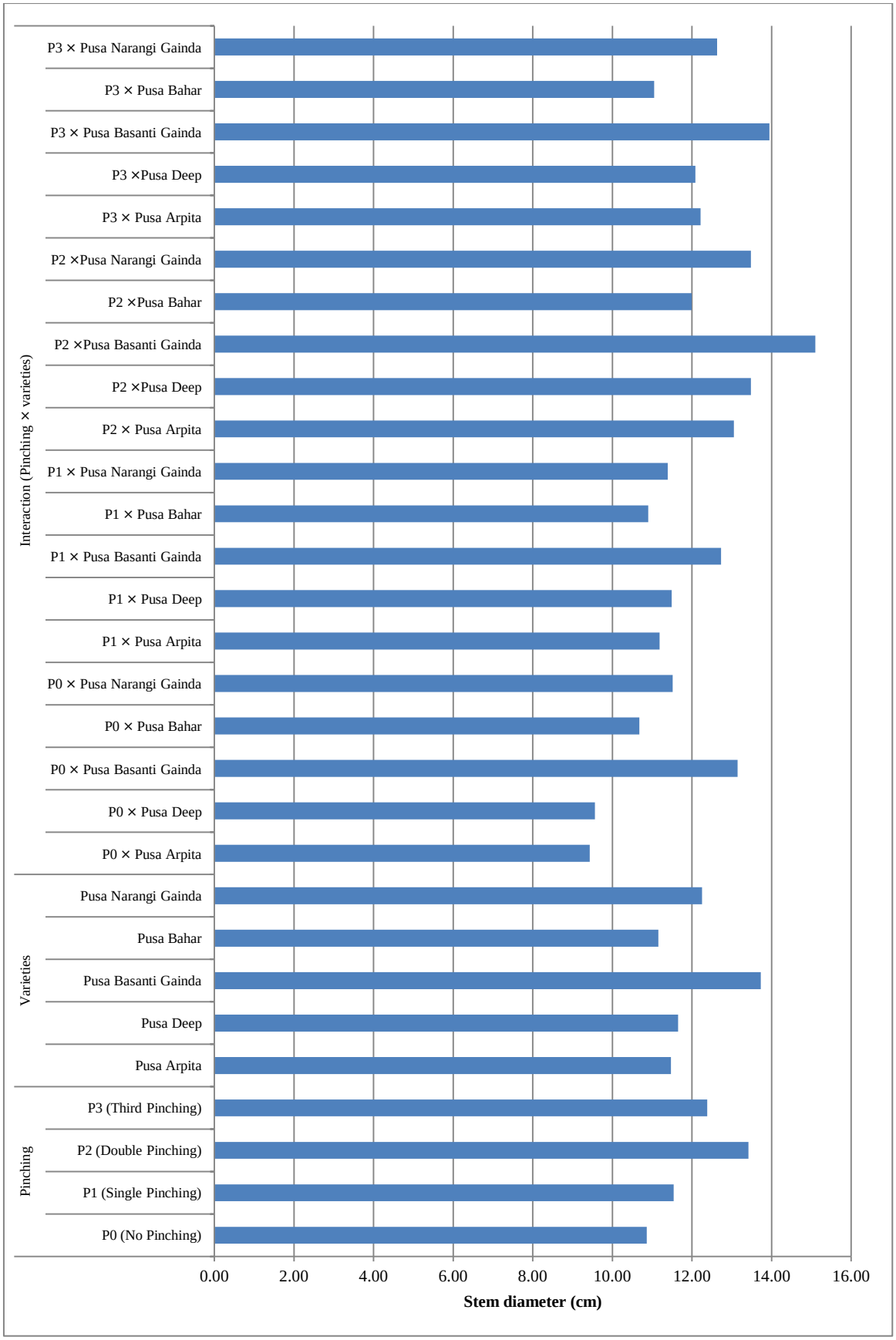


Figure 4.2.1.2. Effect of different level of pinching on stem diameter (cm) in marigold

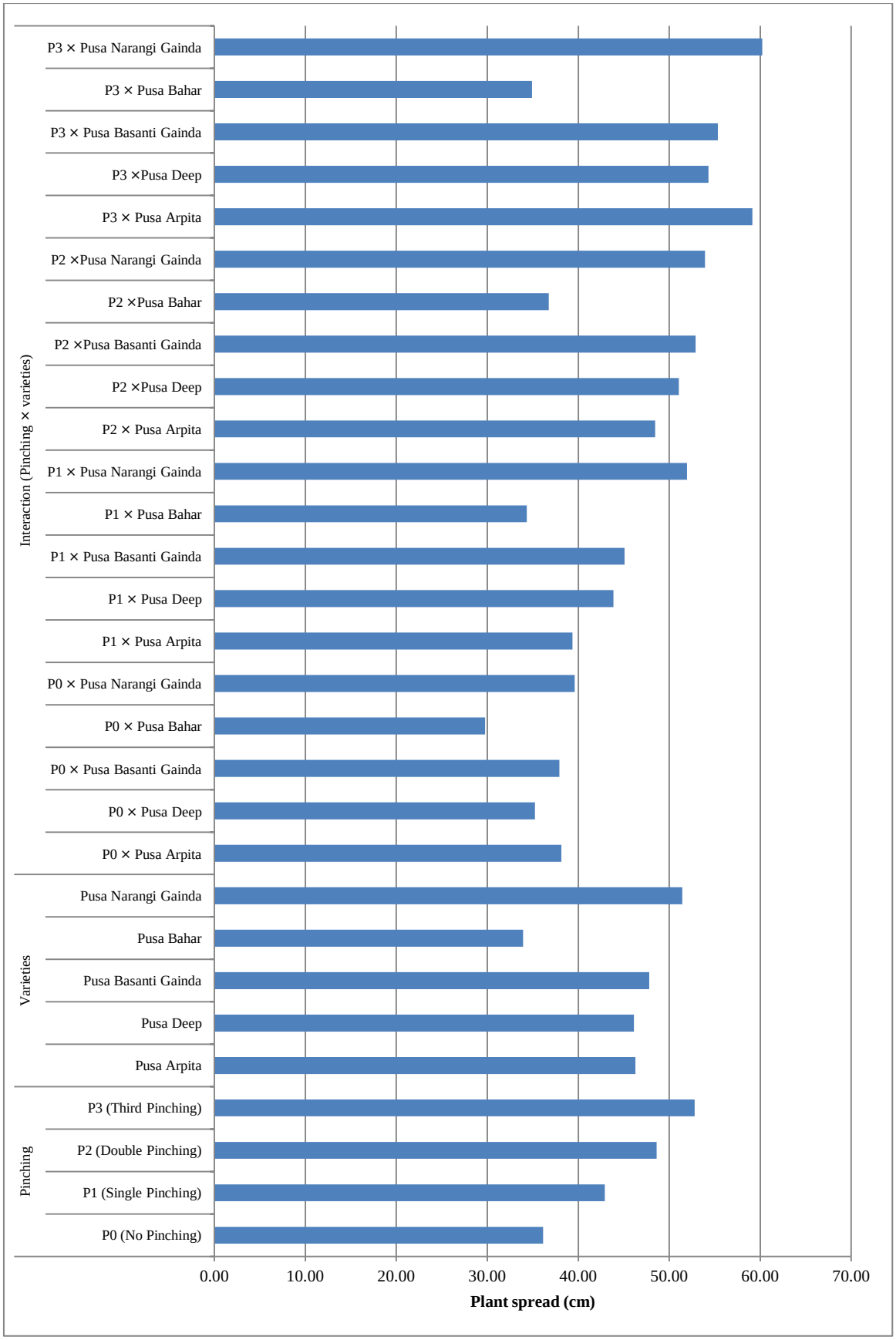


Figure 4.2.1.3. Effect of different level of pinching on plant spread (cm) in marigold

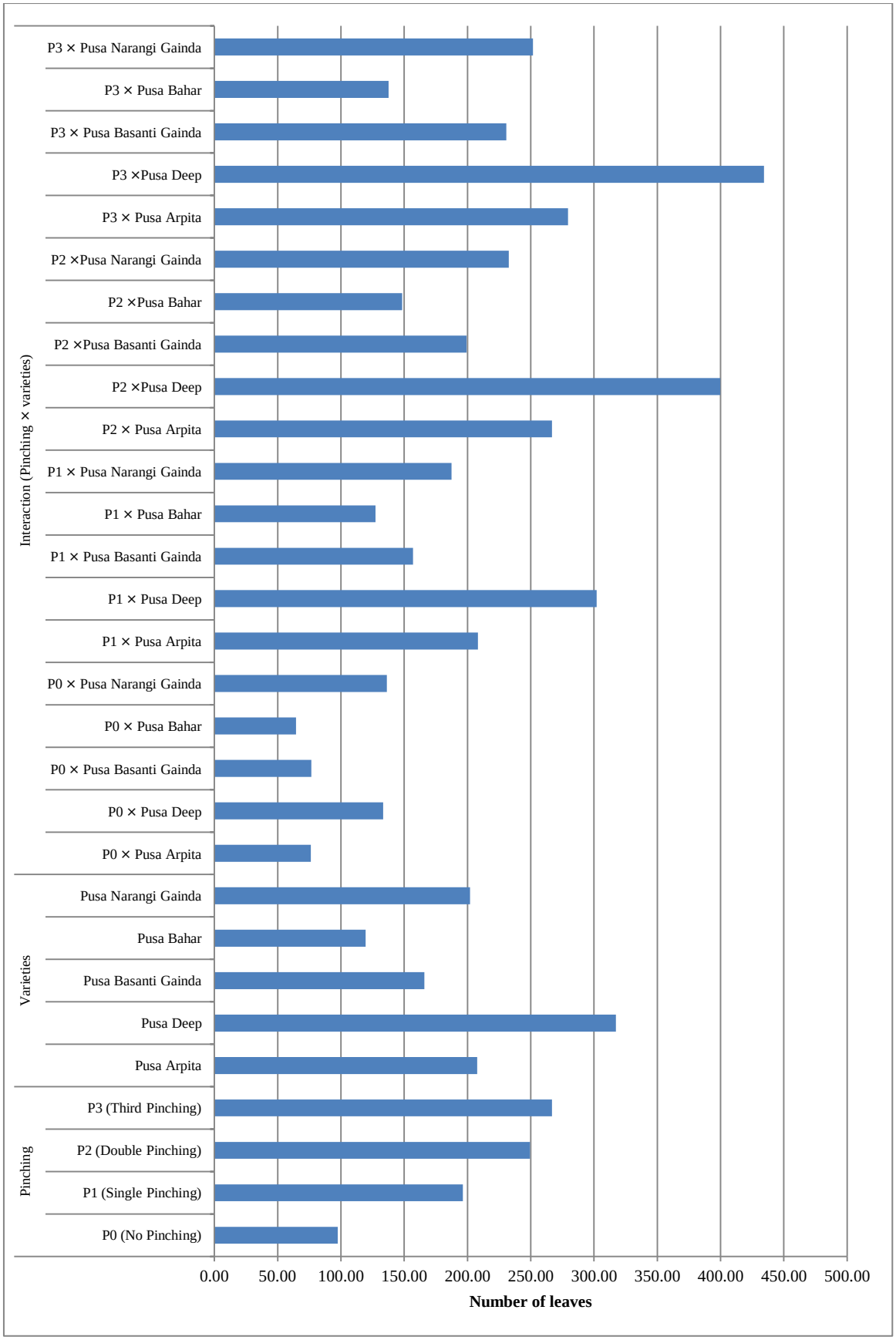


Figure 4.2.1.4. Effect of different level of pinching on number of leaves in marigold

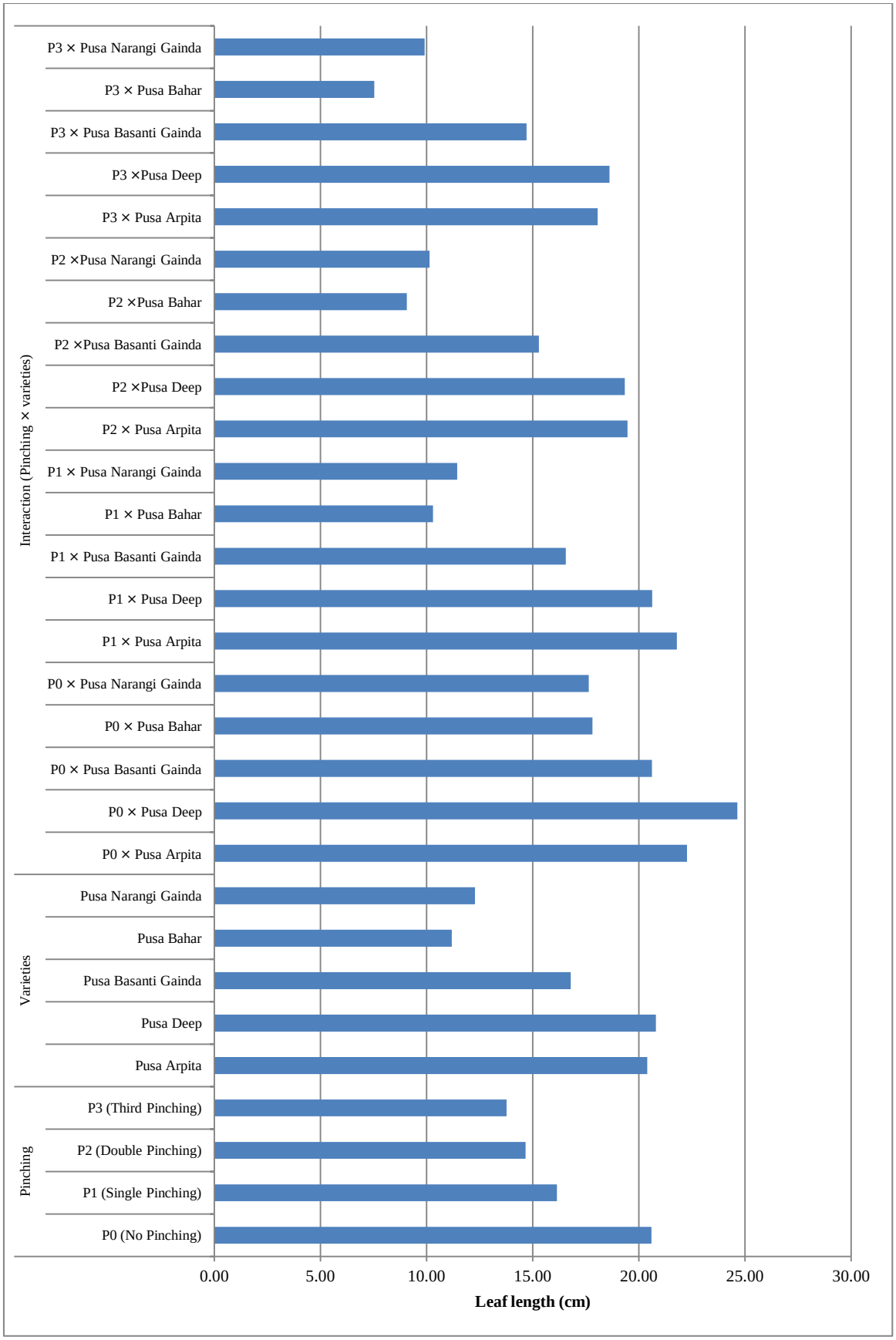


Figure 4.2.1.5. Effect of different level of pinching on leaf length (cm) in marigold

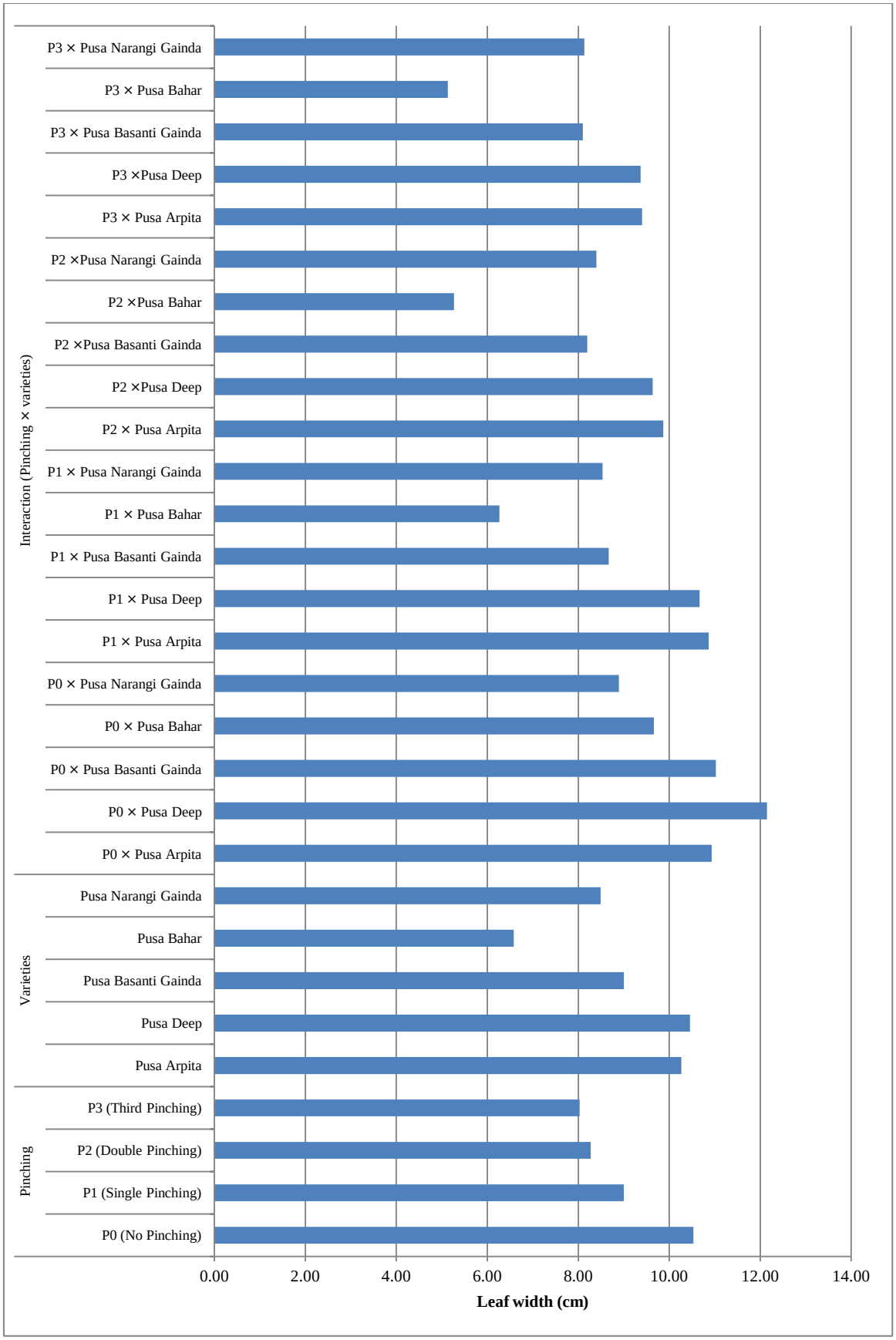


Figure 4.2.1.6. Effect of different level of pinching on leaf width (cm) in marigold

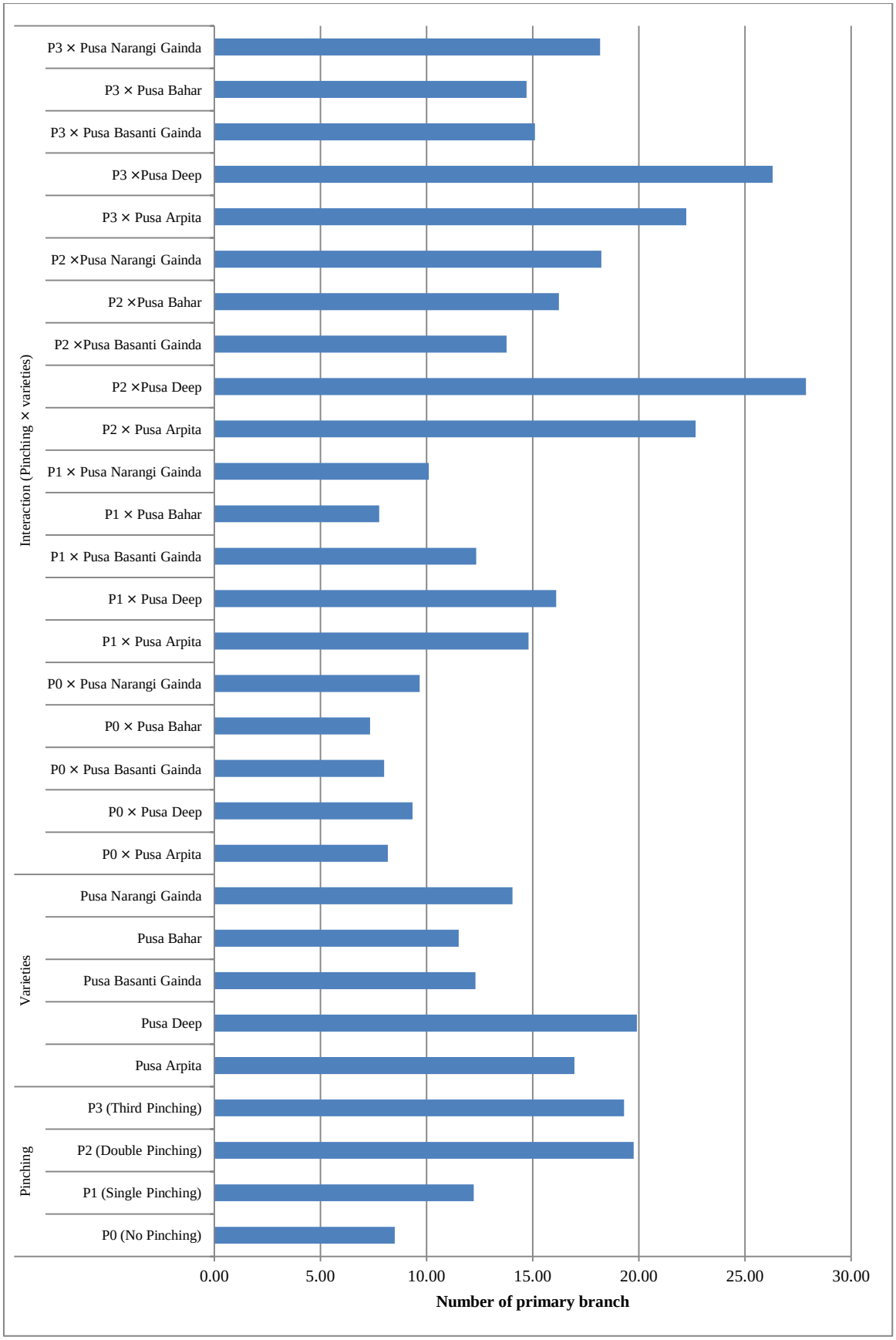


Figure 4.2.1.7. Effect of different level of pinching on number of primary branch in marigold

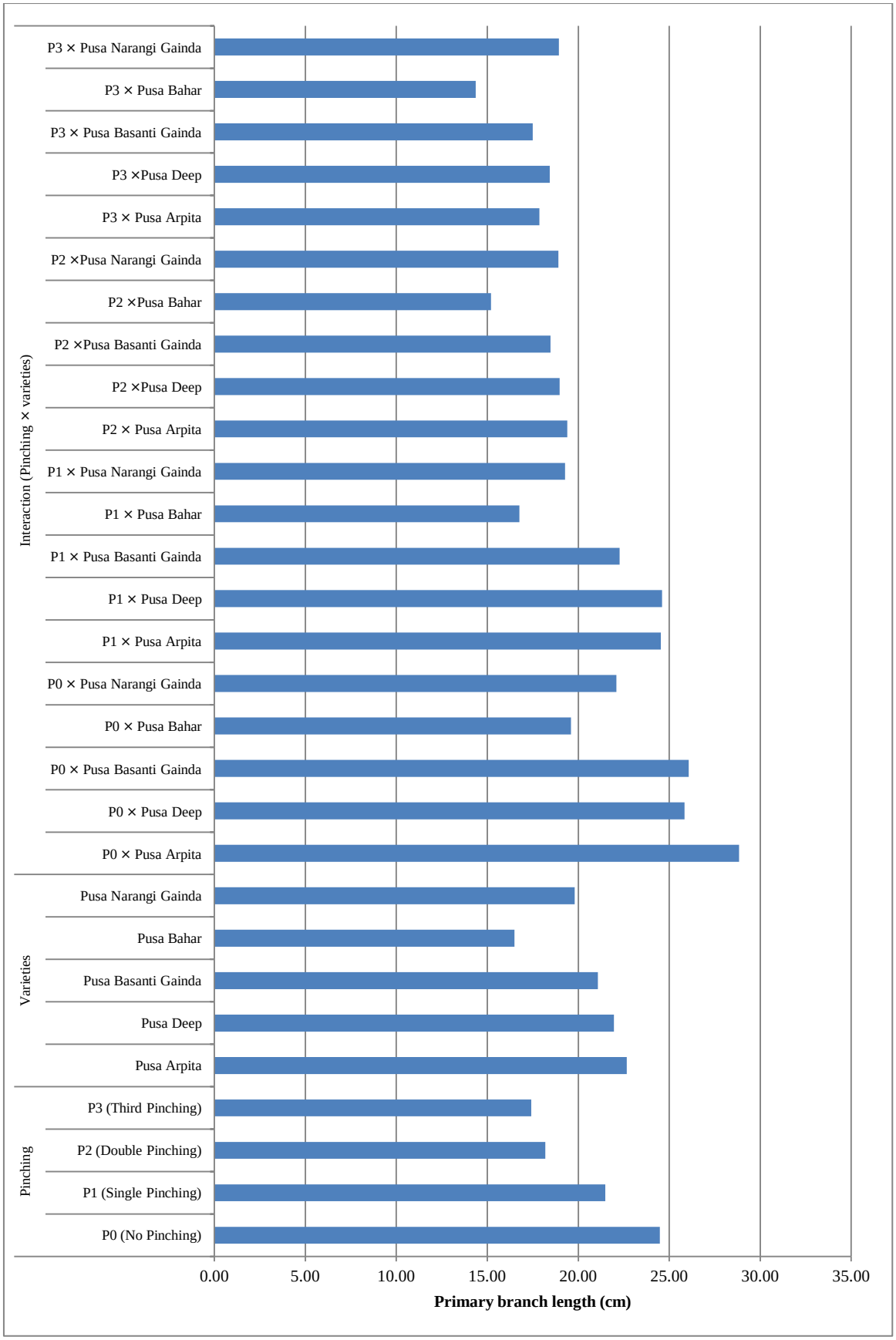


Figure 4.2.1.8. Effect of different level of pinching on primary branch length (cm) in marigold

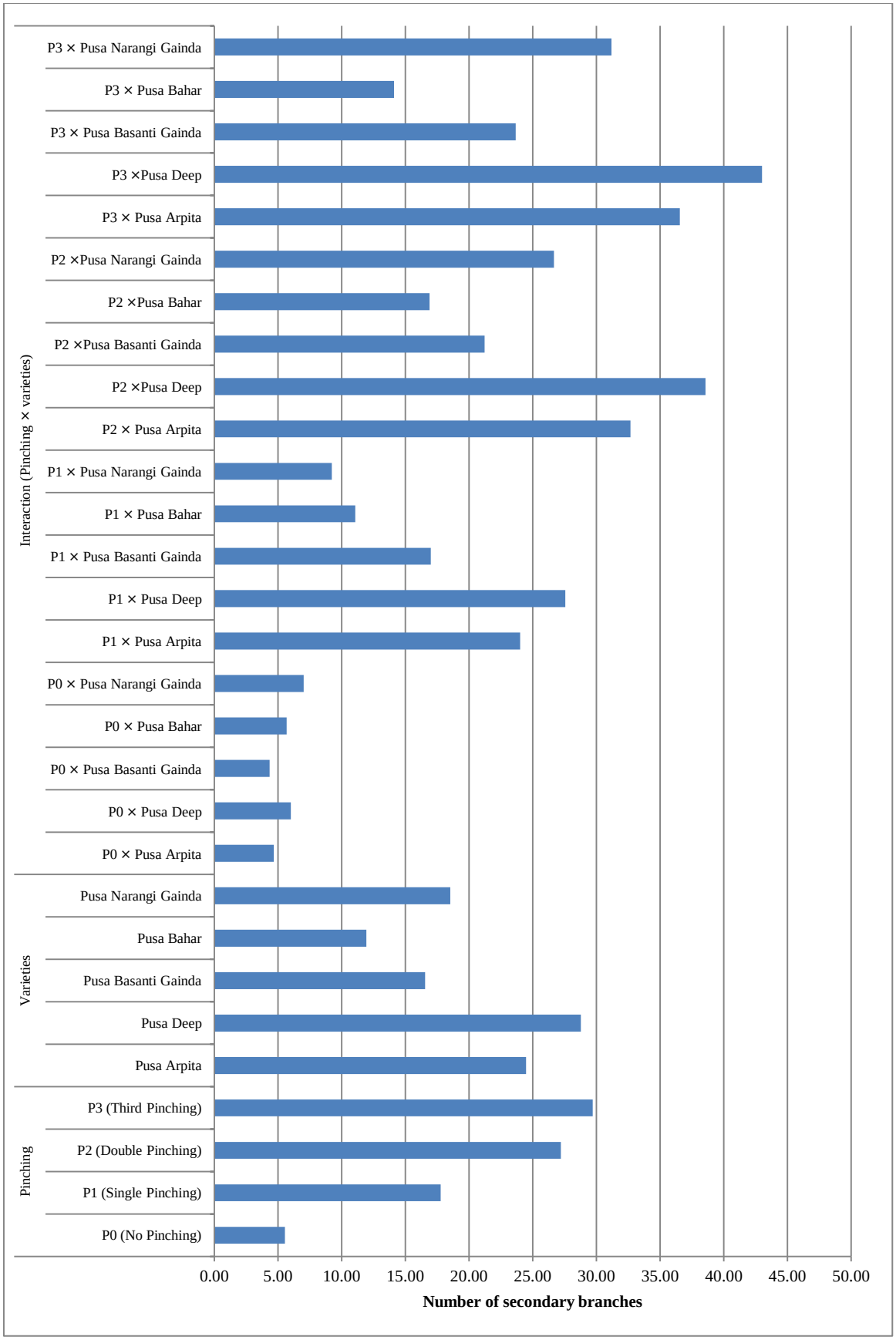


Figure 4.2.1.9. Effect of different level of pinching on number of secondary branches in marigold

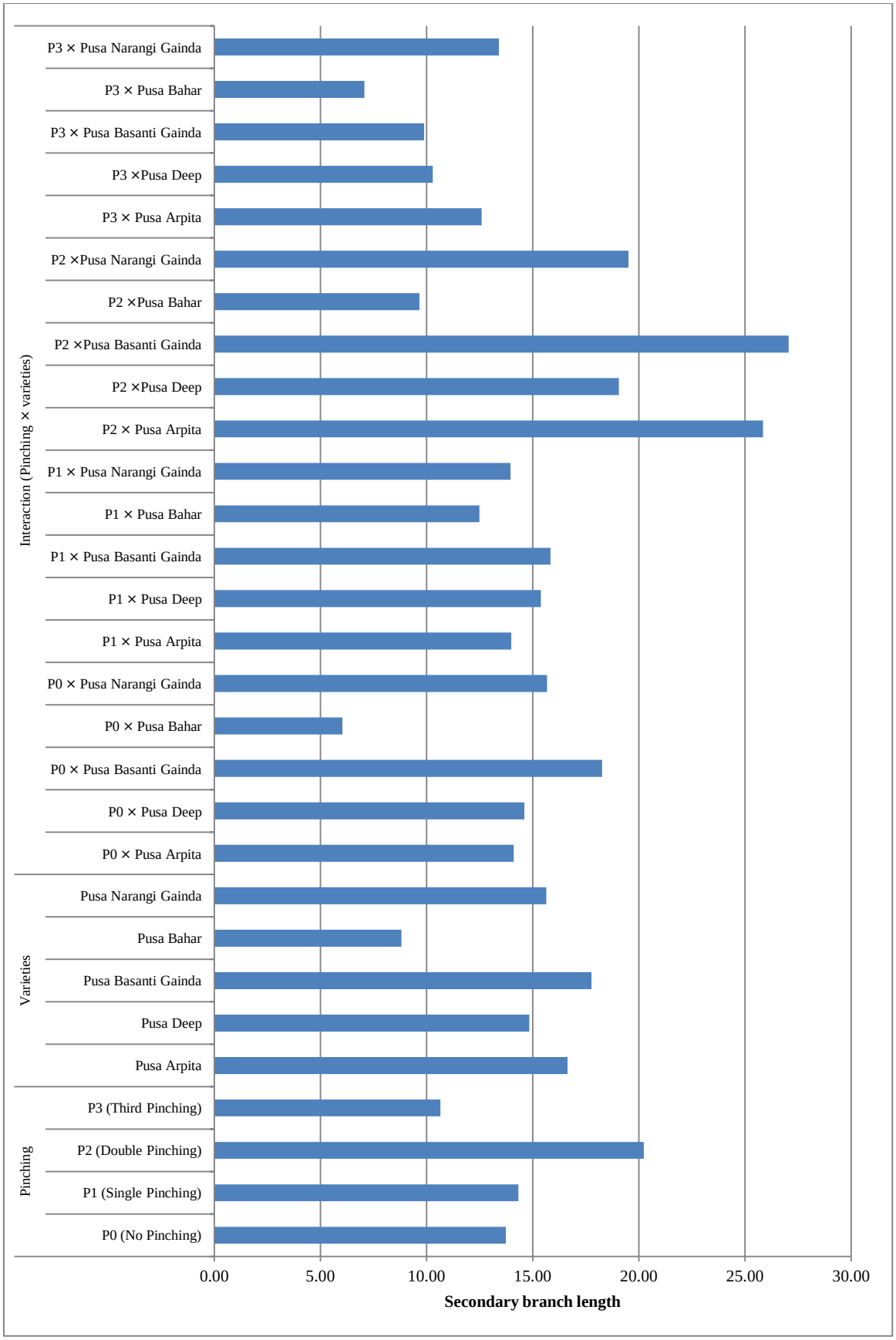


Figure 4.2.1.10. Effect of different level of pinching on secondary branch length in marigold

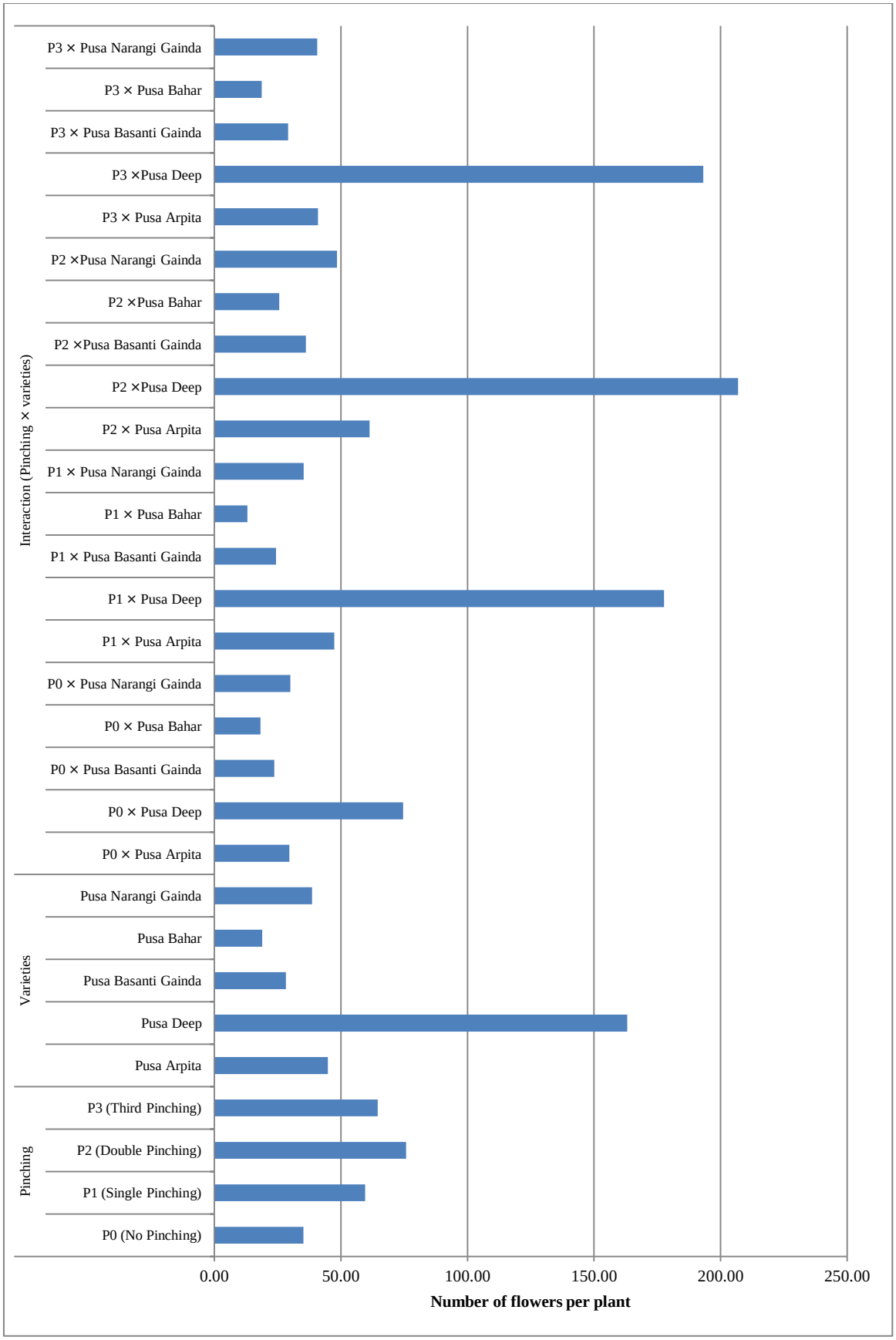


Figure 4.2.2.1. Effect of different level of pinching on number of flowers per plant in marigold

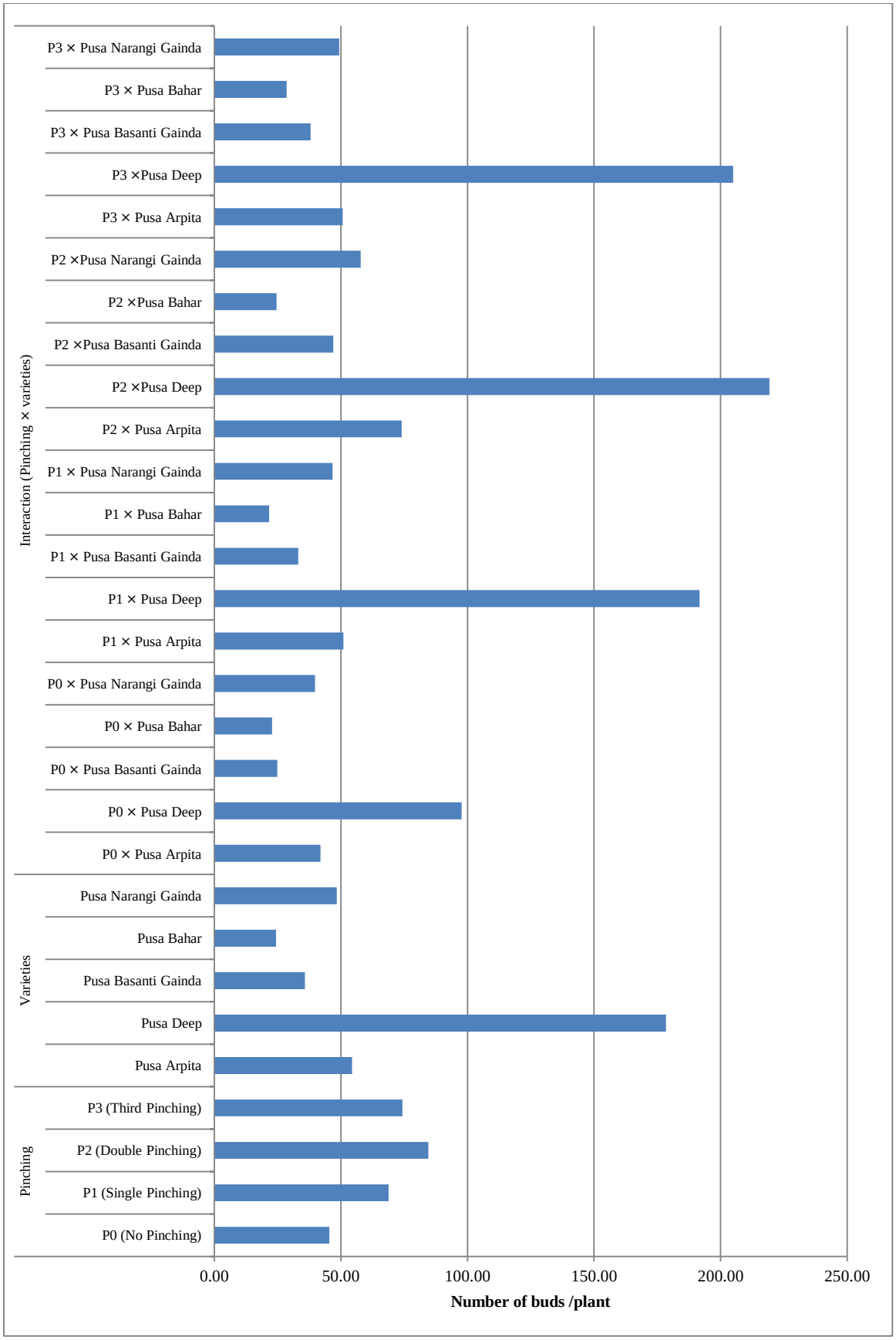


Figure 4.2.2.2. Effect of different level of pinching on number of buds in marigold

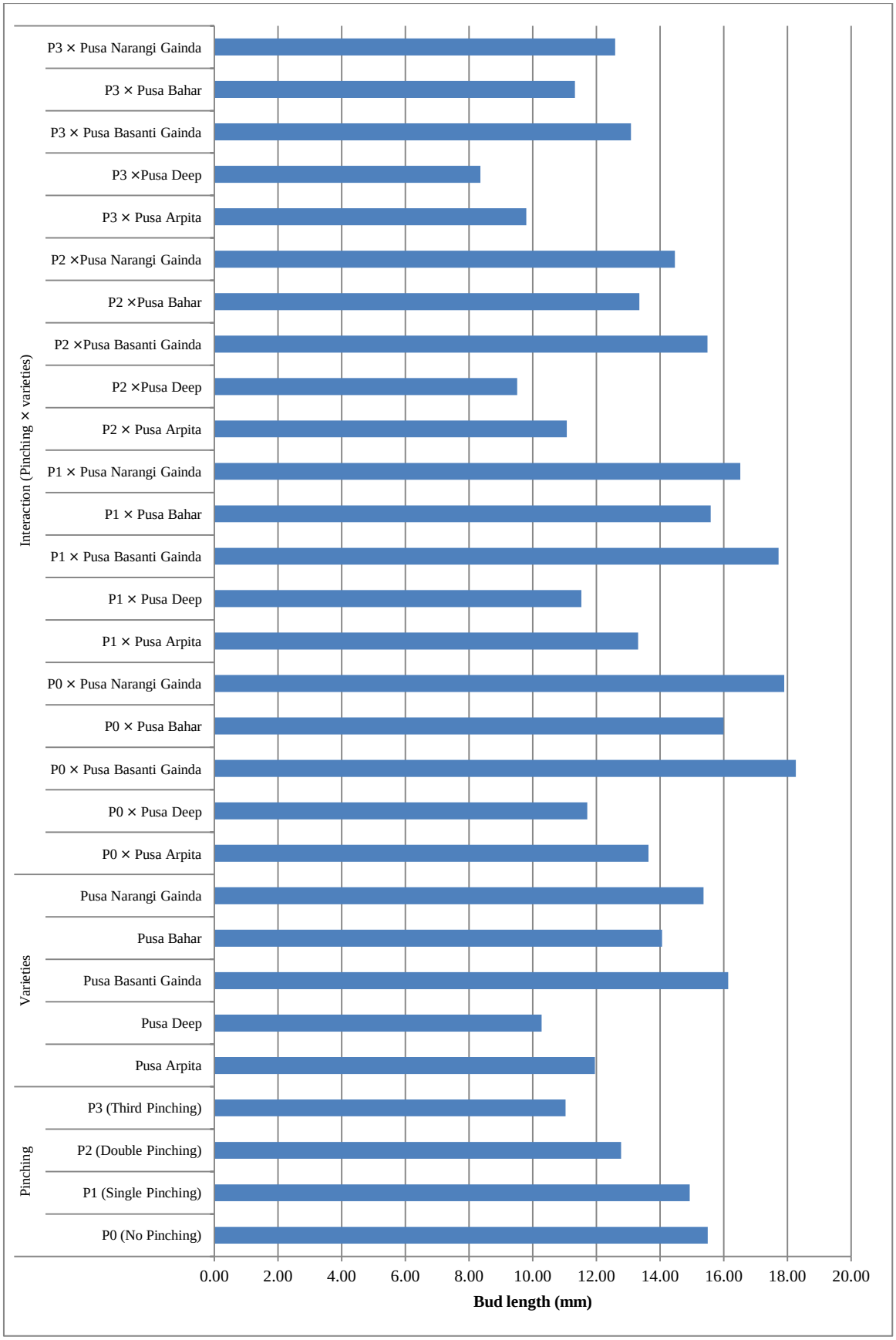


Figure 4.2.2.3. Effect of different level of pinching on bud length (mm) in marigold

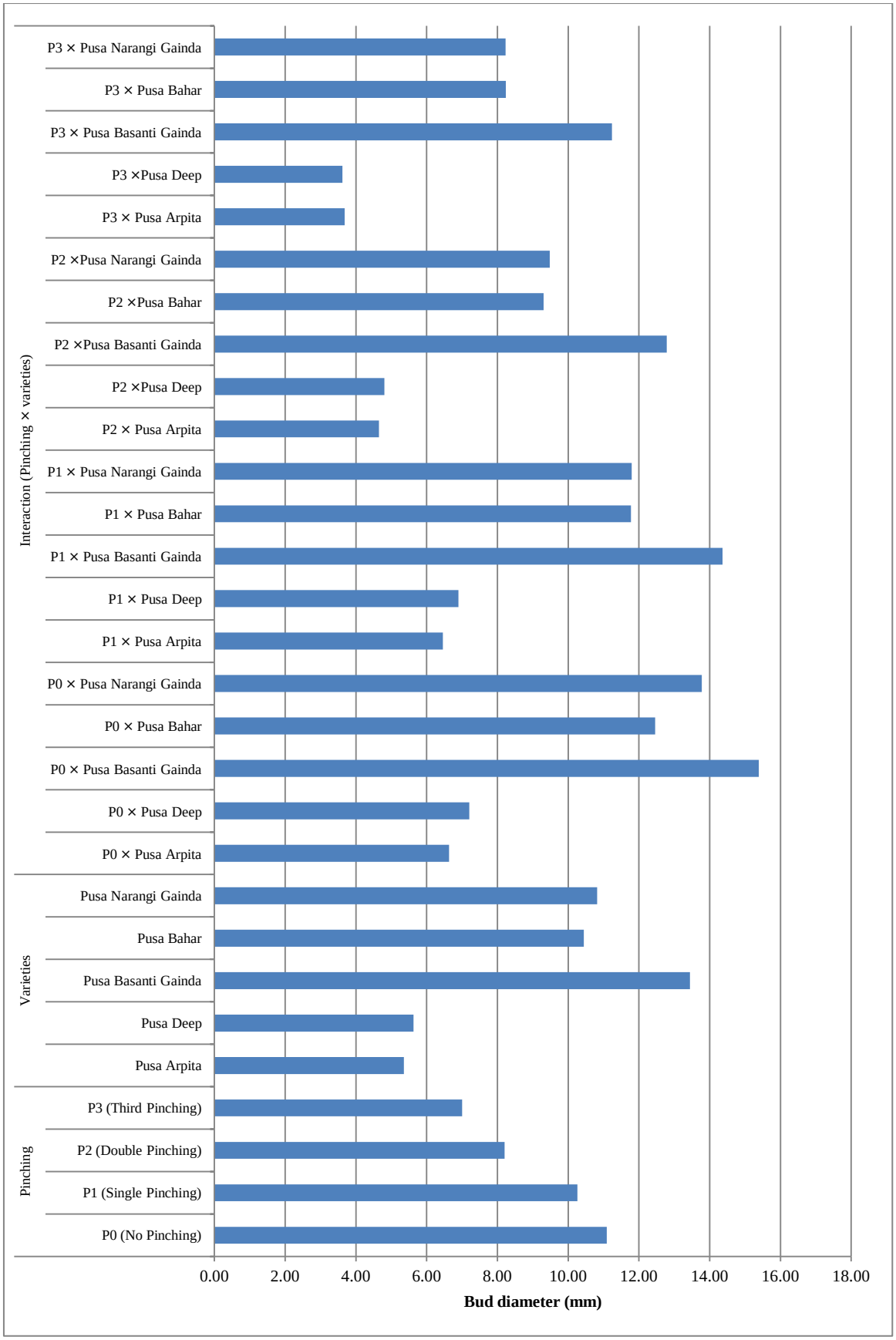


Figure 4.2.2.4. Effect of different level of pinching on bud diameter (mm) in marigold

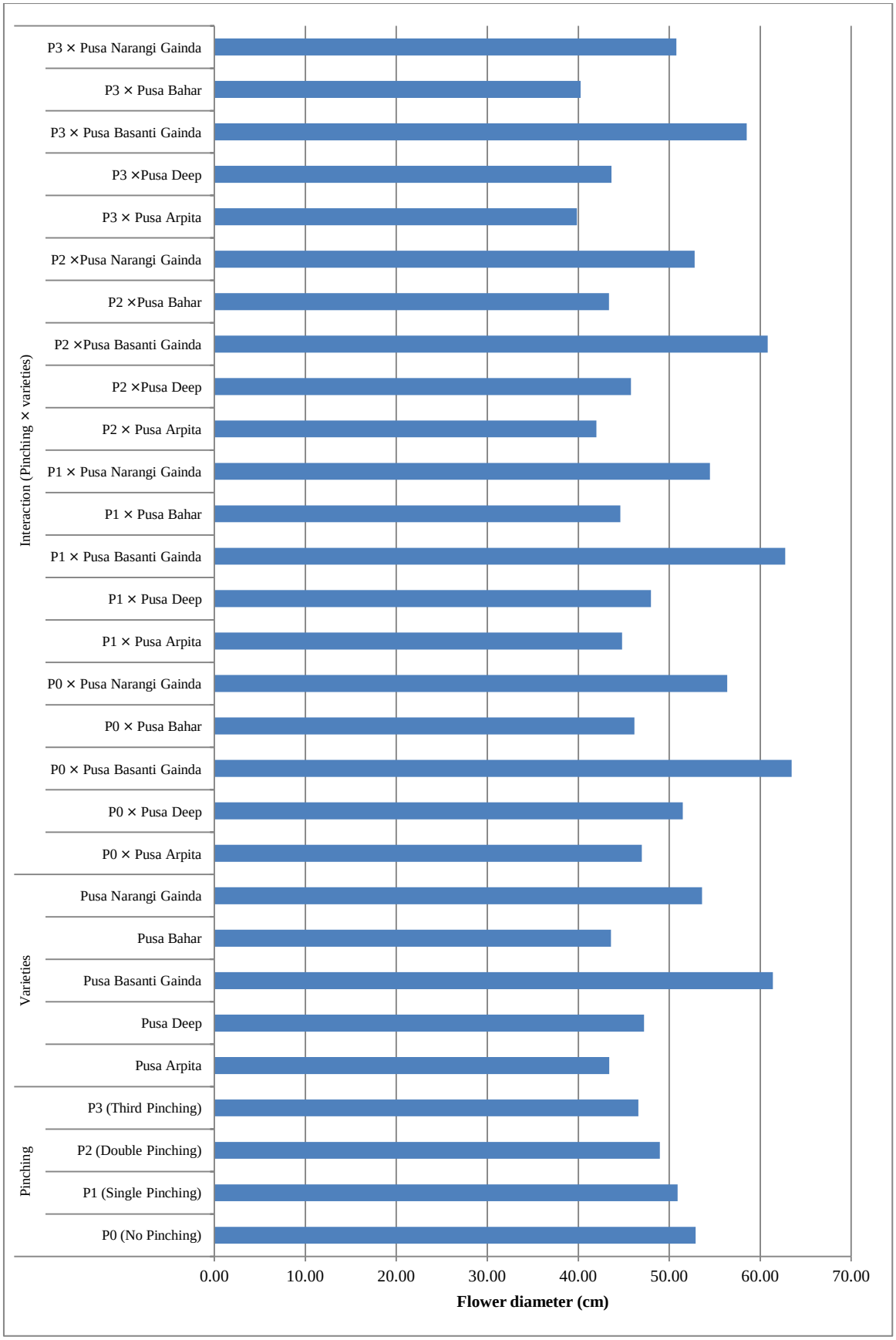


Figure 4.2.2.5. Effect of different level of pinching on flower diameter (cm) in marigold

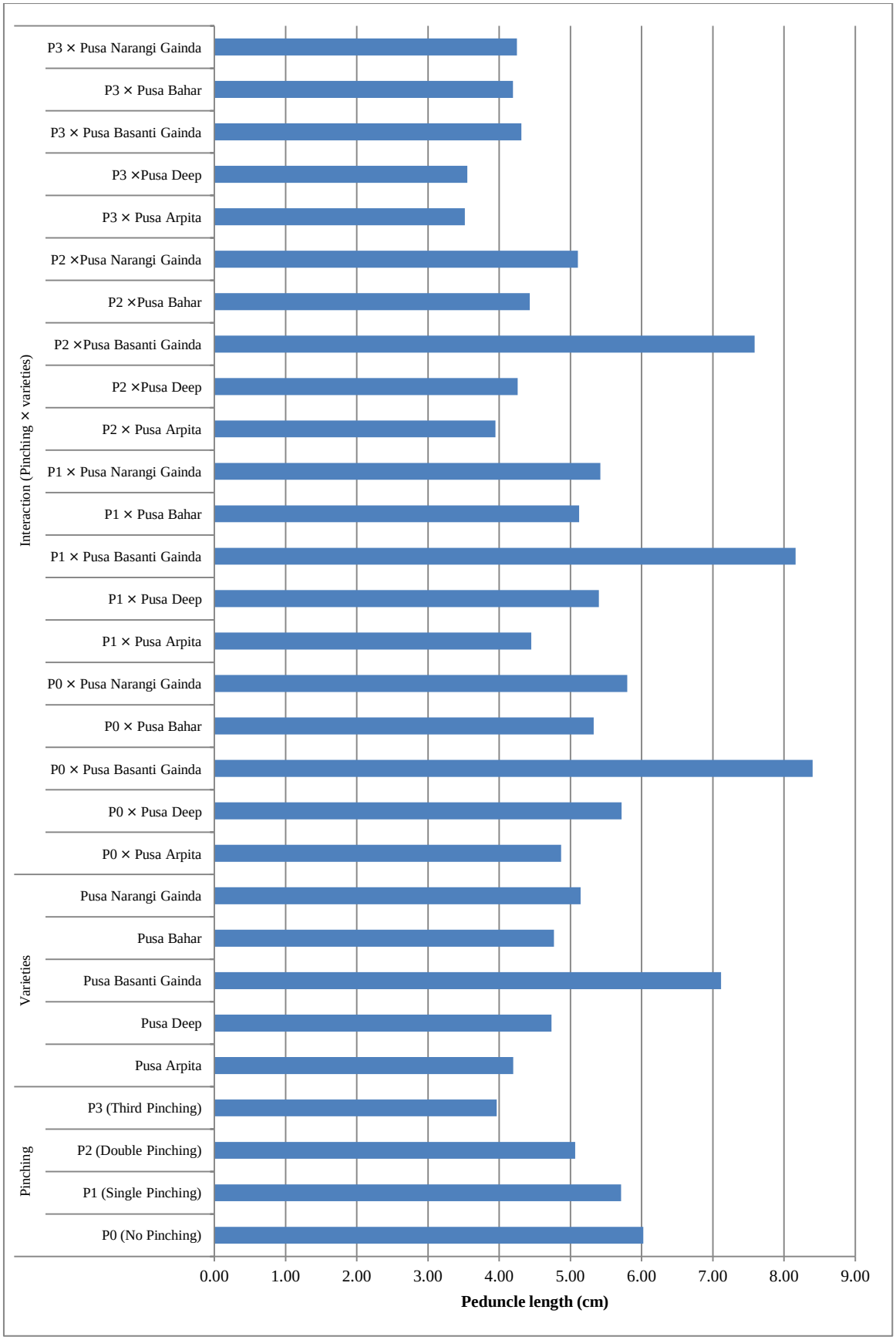


Figure 4.2.2.6. Effect of different level of pinching on peduncle length (cm) in marigold

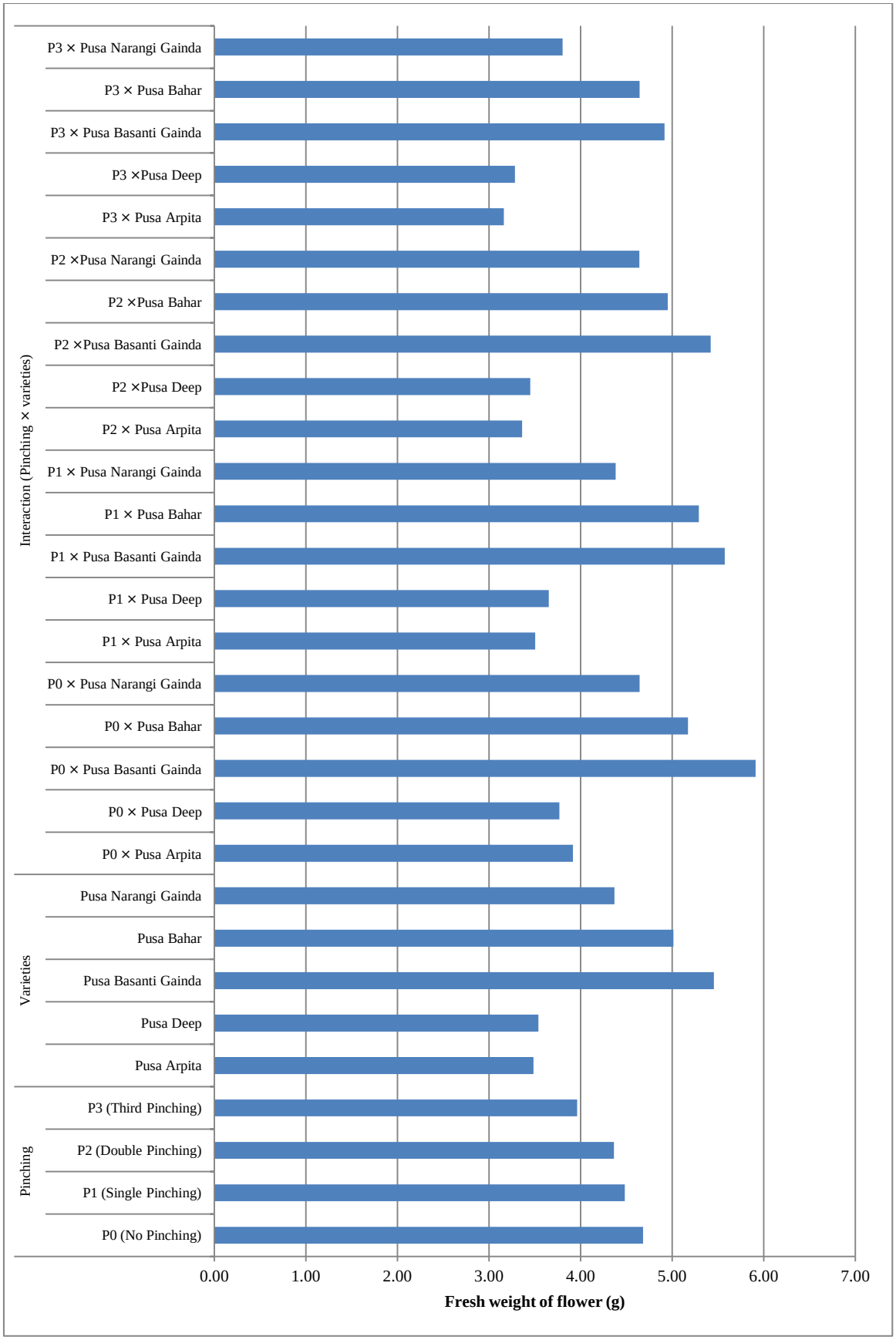


Figure 4.2.2.7. `Effect of different level of pinching on fresh weight of flower (g) in marigold

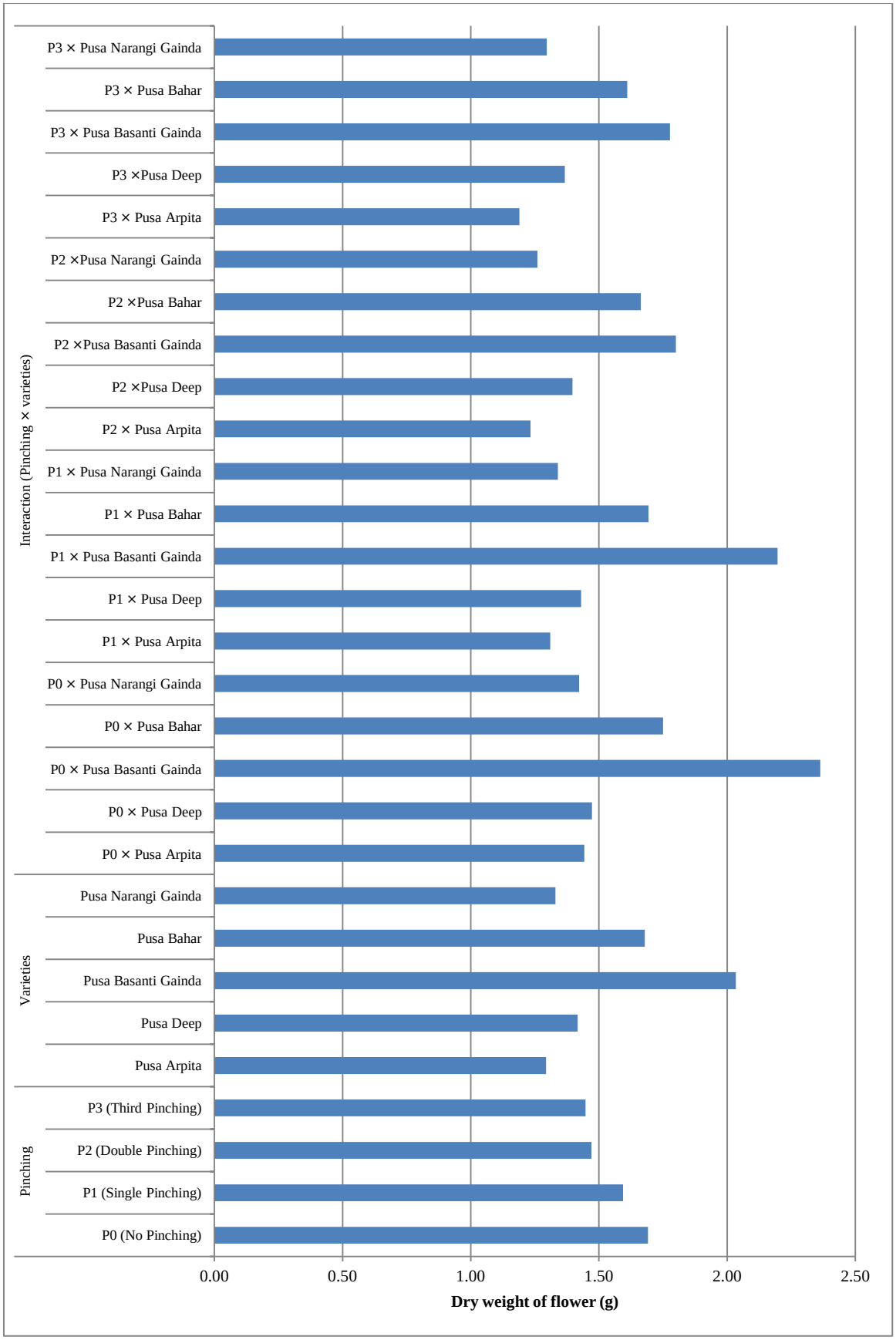


Figure 4.2.2.8. Effect of different level of pinching on dry weight of flower (g) in marigold

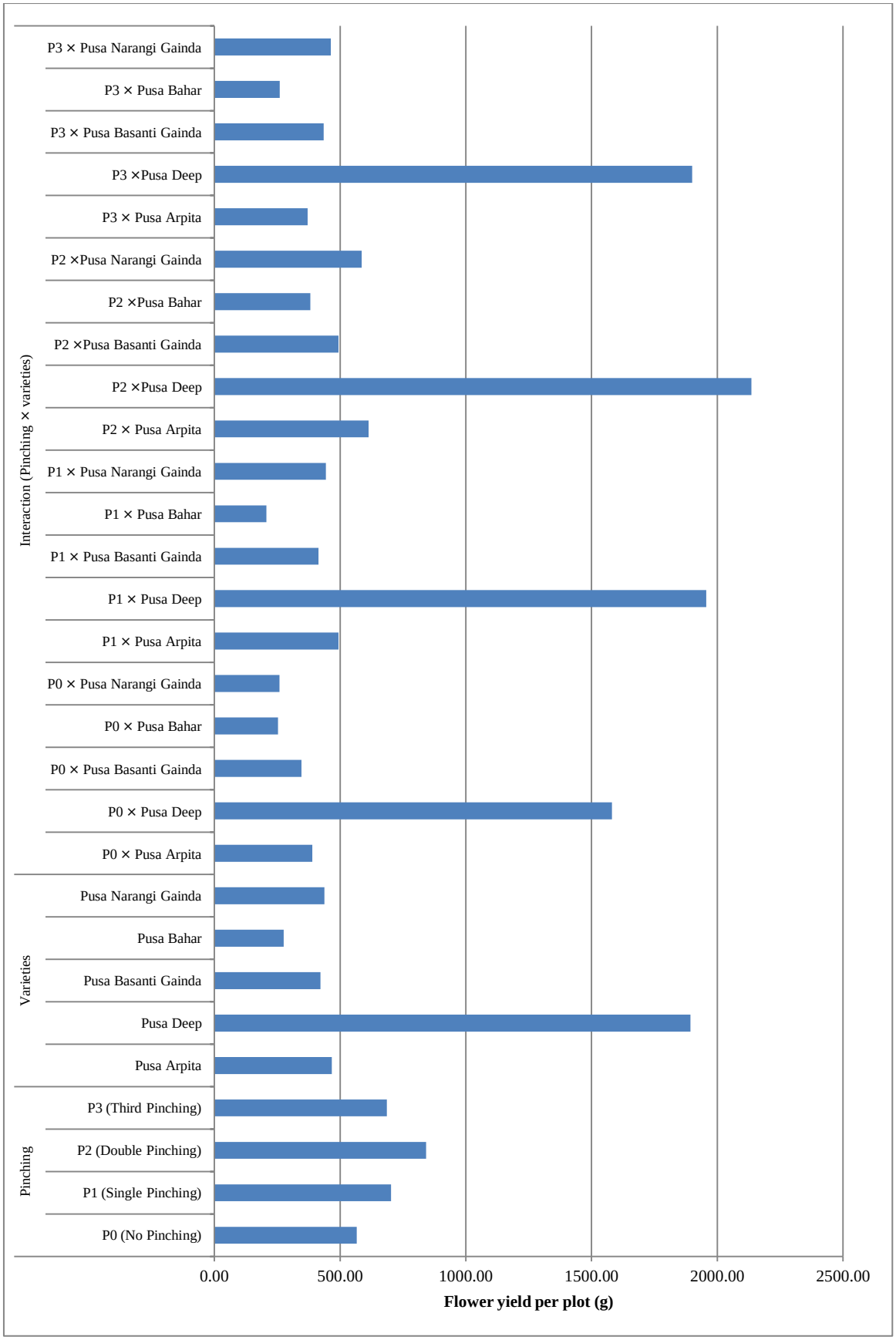


Figure 4.2.2.9. Effect of different level of pinching on flower yield per plot (g) in marigold

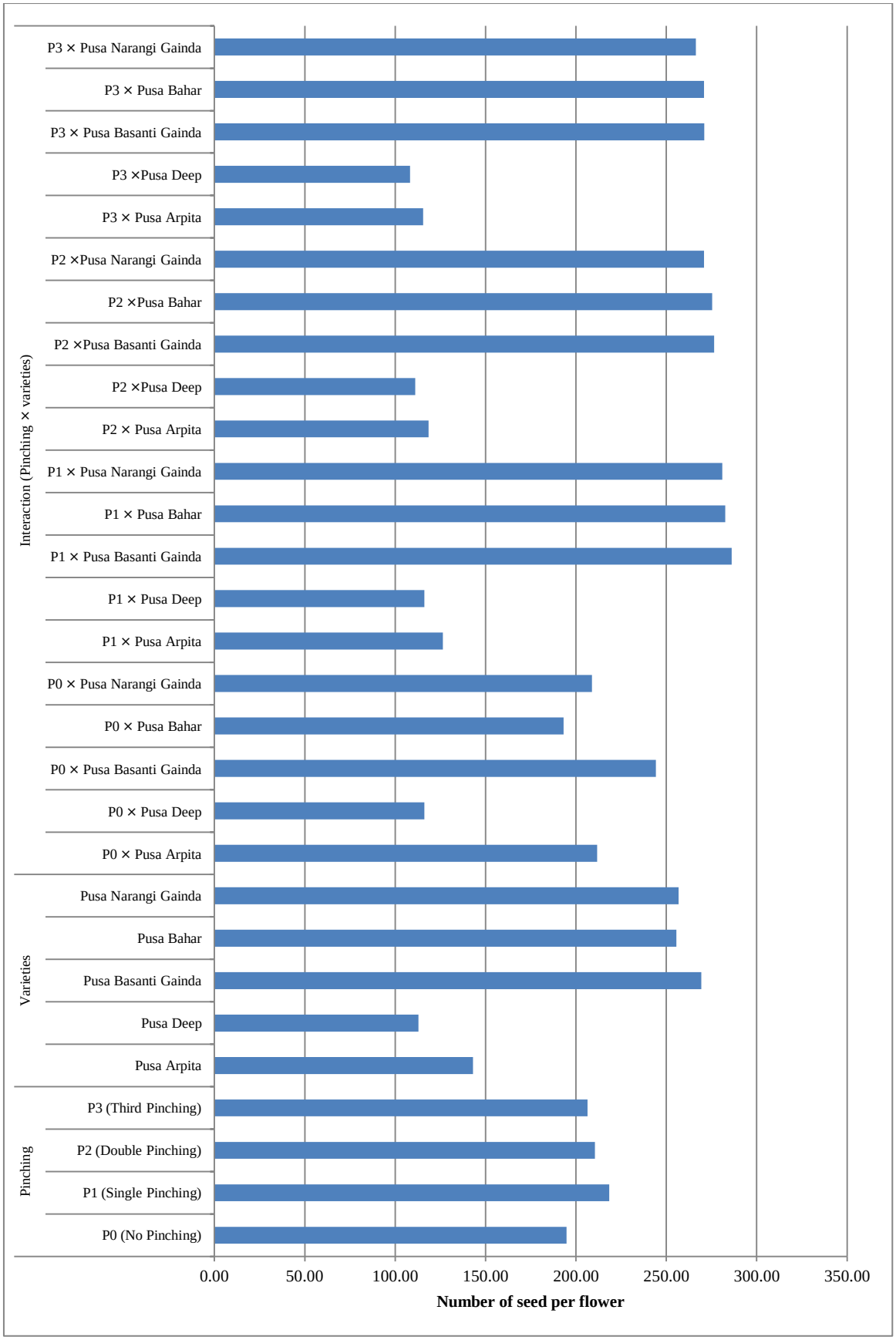


Figure 4.2.3.1. Effect of different level of pinching on number of seed per flower in marigold

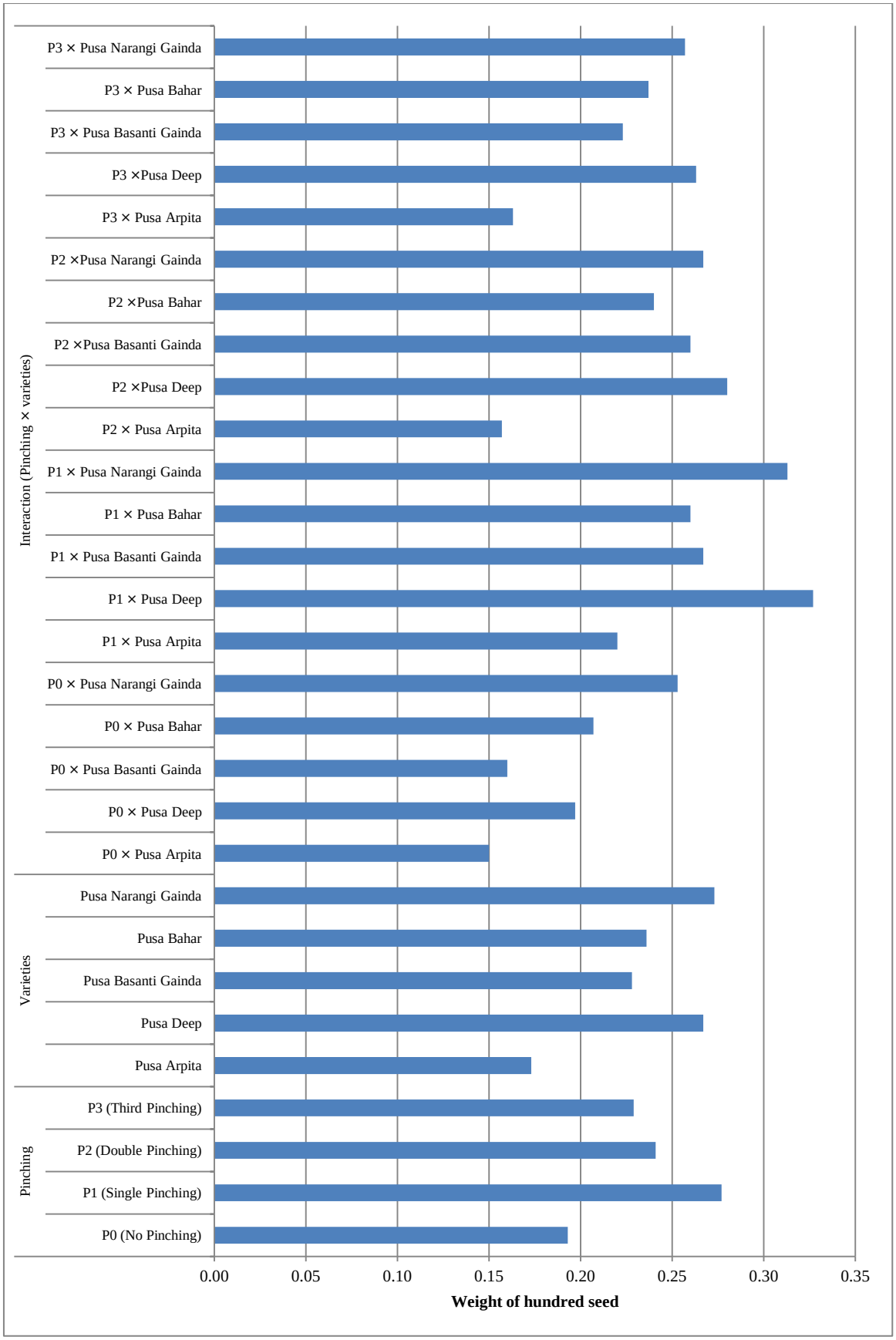


Figure 4.2.3.2. Effect of different level of pinching on weight of hundred seed in marigold

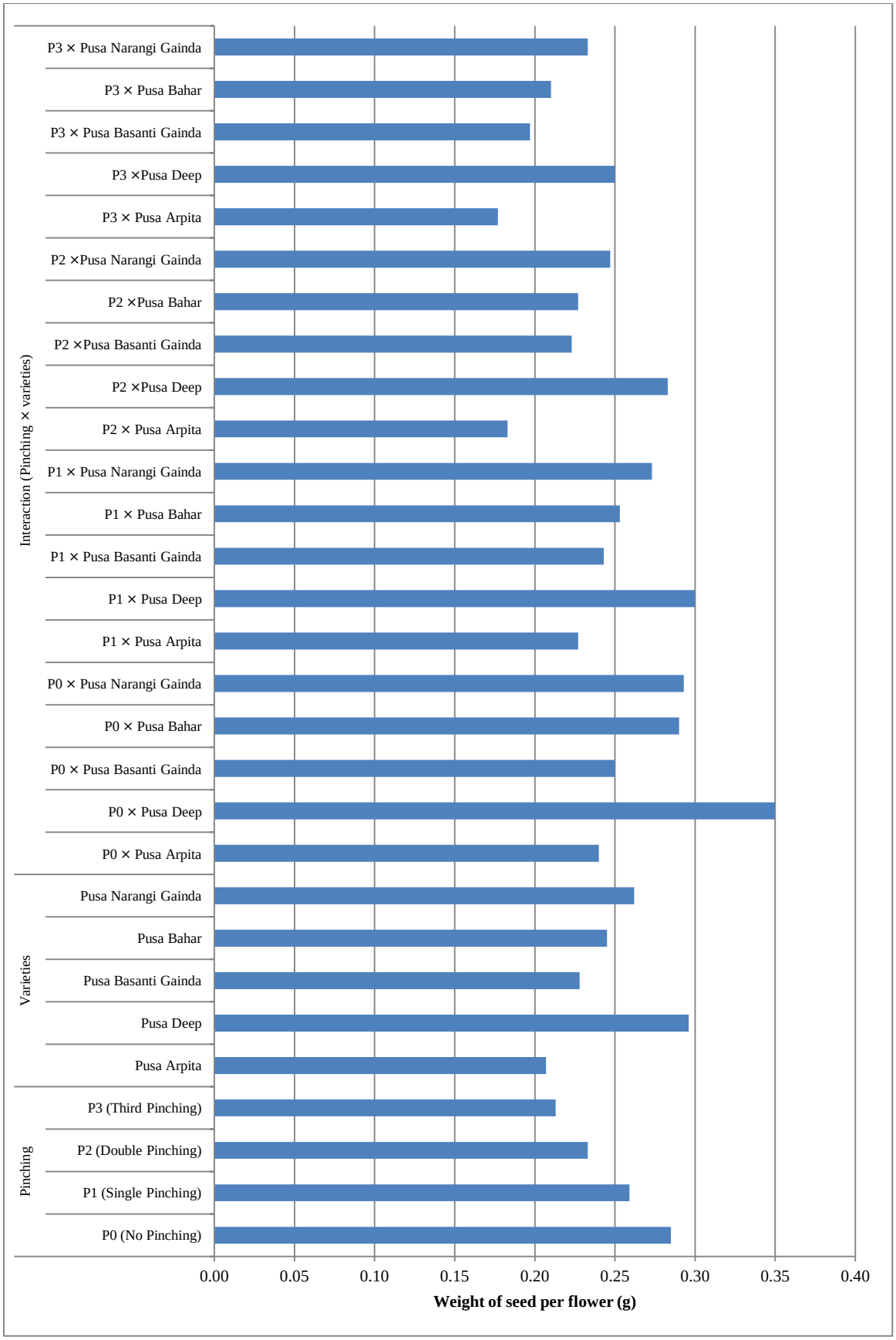


Figure 4.2.3.3. Effect of different level of pinching on weight of seed per flower (g) in marigold

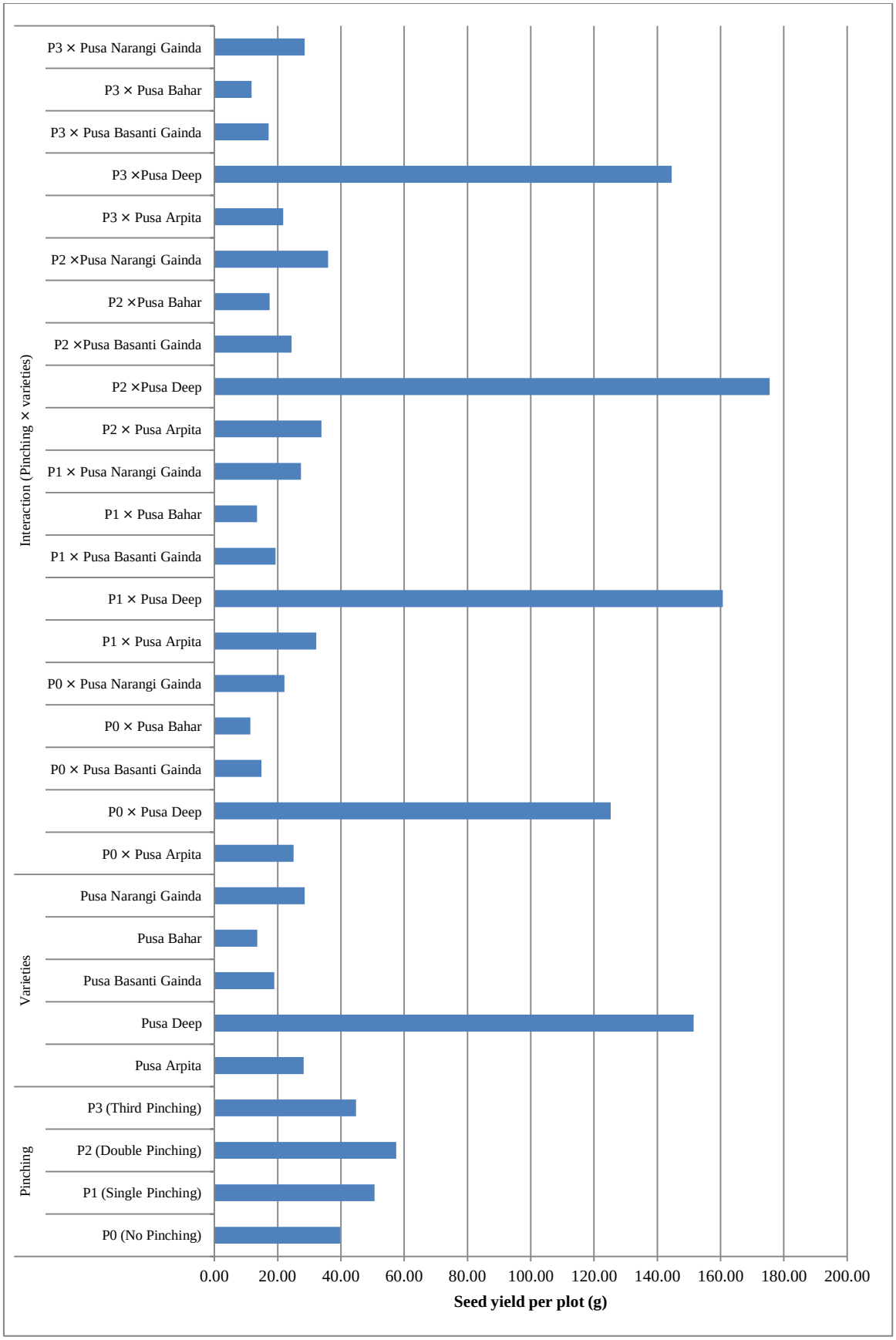
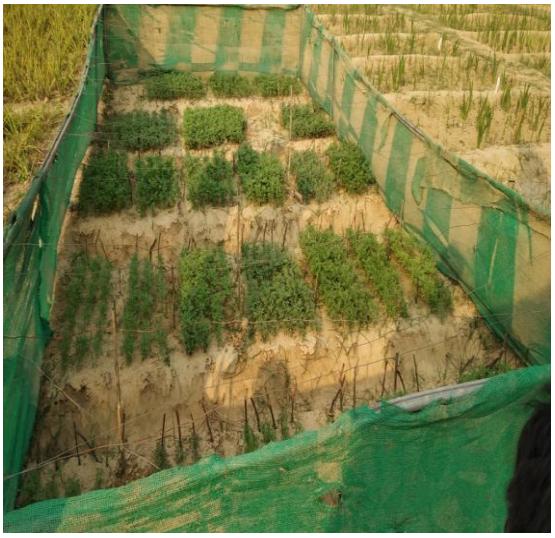


Figure 4.2.3.4. Effect of different level of pinching on seed yield per plot (g) in marigold



Seedlings of marigold at nursery

Uprooting and transplanting of marigold's seedling from nursery to main field

Irrigation of marigold field

Spraying of micro nutrient (zinc) in marigold

Field view of marigold plots before flowering

Field view of marigold plots at flowering

Chapter V

DISCUSSION

An attempt to appraise the findings reported in the experimental findings concerning to the investigation to see the effect of different levels of zinc and pinching on growth, flowering, seed yield and post harvest characters in different varieties of marigold (*Tagetes erecta*). The findings revealed that significant variations exists among most of the treatments and an attempt has been made to discuss the variations observed for growth, flowering, seed yield and post harvest characters. The appropriate discussions in accordance to observed variations recorded during the course of present study are explained with following headings.

5.1 Effects of different levels of zinc on growth, flowering, seed yield and post-harvest characters in marigold

5.1.1 Effect of different levels of zinc on growth characters

5.1.1.1 Plant height

It is apparent from the study that a significant effect was observed on plant height due to effect of various zinc doses on different varieties of marigold and their interactions. Application of zinc @ of 0.5% resulted in maximum plant height (43.50 cm), while minimum plant height was recorded in control (39.60 cm). Among the different varieties of marigold maximum plant height was recorded in variety Pusa Basanti Gainda (55.20 cm) and the minimum plant height was found in Pusa Deep (25.20 cm). Studies among the interactions revealed that treatment combination of zinc 0.5% × Pusa Basanti Gainda resulted the maximum plant height (70.43 cm), while minimum leaf width was reported in zinc 0.5% × Pusa Deep (24.08 cm). The increase in vegetative growth by application of zinc sulphate in marigold might be due to synthesis of tryptophan, a precursor of indole acetic acid (auxin) accelerated by zinc which helps the plant to maintain apical dominance, polarity and growth. The plant of height of Pusa Basanti Gainda was also found maximum among all the varities due to its varietal characters that was inherited from parent followed by Pusa

Narangi Gainda. The results are in line with the findings of Dashora and Verma (2004), Shah *et al.* (2016) and Jat *et al*., 2007 in African marigold, kakade *et al*. (2009) in china aster, Khosa *et al*. (2011) in gerbera, Khalifa *et al*. (2011) in iris plants. Similar findings were also obtained by Rahmati *et al*., (2009) in pot marigold.

5.1.1.2 Stem diameter (mm)

A statistical significant effect was observed with stem diameter owing to various doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc in different varieties of marigold and their studies of interactions. Maximum stem diameter was recorded with zinc treatment of 0.5% zinc (11.16 mm), while minimum stem diameter was recorded in control (9.33 mm) followed by 1.0% zinc (9.80 mm). Among different varieties of marigold Pusa Narangi Gainda resulted the maximum stem diameter (11.28 mm), while minimum stem diameter with Pusa Arpita (9.14 mm). Interaction of 0.5% zinc with Pusa Basanti Gainda resulted in maximum stem diameter (13.14 mm), while minimum stem diameter was observed in interaction zinc 0.8 % × Pusa Arpita (8.2 mm). In plants, zinc is an essential element of cell component of various cell membranes which helps in cell membrane maintenance and induce cell division that resulted enhanced vegetative growth. The increased stem diameter might be due to accumulation of photosynthesis materials. The findings are in conformity with the results of Shah *et al.* (2016) in marigold, John and Paul (1999) and Belgaonkar *et al*. (1996) in chrysanthemum.

5.1.1.3 Plant spread (cm)

Various doses of zinc and different varieties in marigold had shown a significant effect on spread of the plant. Maximum value of plant spread was resulted in treatment dose of 0.5% zinc (44.60 cm), while minimum spread of plant was established in 0.7% zinc (38.89 cm) followed by control (39.31 cm). Among the varieties of marigold the maximum value of plant spread was observed in Pusa Deep (49.30 cm), while minimum spread of plant was recorded in Pusa Bahar (28.37 cm). The interaction effect of zinc doses with various varieties in marigold failed to exert any significant effect on spread of plant. The increase in spreading of plants might be

due to induced cell division resulted in enhanced vegetative growth and biomass. As a result, the accumulated carbohydrates formed due to photosynthesis helps in spreading plants and their parts. The results are in line with the findings of kakade *et al*. (2009) in China aster, Kendra *et al*. (2013) in chrysanthemum.

5.1.1.4 Number of leaves per plant

Significant effects were exhibited regarding the number of leaves per plant due to various doses of zinc, varieties of marigold and their interactions. Maximum numbers of leaves per plant were recorded with the application of 0.5% zinc (113.86), while minimum numbers of leaves per plant were recorded in the control (97.89). Whereas maximum numbers of leaves per plant were observed by the variety Pusa Narangi Gainda (188.92), while minimum numbers of leaves per plant were resulted by variety Pusa Arpita (67.11). Treatment combination of 1.0% zinc with Pusa Narangi Gainda gave maximum numbers of leaves per plant (229.87), while the minimum number of leaves per plant was resulted in interaction study the Zinc 0.8% × Pusa Bahar (57.93). Application of zinc significantly increased the number of leaves per plant which might be due to induced cell division with more accumulation of photosynthesis materials. The findings are in conformity with the results of Shah *et al.* (2016) in marigold, John and Paul (1999) and Belgaonkar *et al.* (1996) in chrysanthemum.

5.1.1.5 Leaf length (cm)

Maximum leaf length (20.09 cm) was registered with application of 0.5% zinc, while 1.0% zinc gave the minimum length of the leaf (18.04 cm). Among all varieties in marigold Pusa Deep gave the maximum leaf length (23.71 cm), while minimum length of the leaf was recorded by Pusa Bahar (17.06 cm). Among the interaction of zinc doses (control, 0.5%, 0.7%, 0.8% and 1.0%) and marigold varieties, combination of 0.7% zinc with Pusa Deep (26.09 cm) significantly gave maximum leaf length, while minimum leaf length was recorded in Zinc 1.0 % × Pusa Bahar (14.06 cm). The increase in length of leaves might be due to storage of more carbohydrates favoured by zinc application which might help in reducing juvenile phase of plants (Kendra *et*

al., 2013). Similar results are also obtained by Balkrishnan *et al*. (2007) in African marigold.

5.1.1.6 Leaf width (cm)

Maximum leaf width (10.55 cm) was obtained with 0.5% zinc, while minimum with 1.0% zinc (9.68 cm). Among the different varieties of marigold maximum leaf width was found in variety Pusa Deep (12.11 cm) and minimum with Pusa Basanti Gainda (9.05 cm). Interaction of 0.5% zinc with Pusa Deep gave the maximum leaf width (13.22 cm) and minimum with zinc 1.0 % × Pusa Basanti Gainda (7.46 cm) treatment. This might be due to application of micro nutrient (zinc) favours in storing more carbohydrates in leaves that helps in induced cell division process. The widening of leaves might be due to stimulated cell division in plant parts including leaves. The findings are in line with the results of Kendra *et al*. (2013) in chrysanthemum and Ganesh *et al*. (2013) in tuberose.

5.1.1.7 Number of primary branches per plant

The results revealed that the number of primary branches per plant significantly influenced due to different zinc doses, various variety of marigold and their interactions. Significantly maximum number of primary branches per plant was recorded under the treatment doses of 0.5% zinc (13.11), while minimum with control (10.99). Among the varieties the maximum number of primary branches per plant was observed in variety Pusa Deep (13.31) and minimum with Pusa Basanti Gainda (10.71). The interaction of 0.5% zinc with Pusa Narangi Gainda gave maximum number of primary branches per plant (15.40) and minimum with Zinc 0.0 % × Pusa Arpita (6.67). Pusa Deep bears more number of primary branches as compared to other varieties of marigold, But on the other hand this increased in vegetative growth characters might be due to application of zinc sulphate might be on account of synthesis of tryptophan, a precursor of indole acetic acid (auxin), which is accelerated by zinc and as such helps the plant to maintain apical dominance, polarity and growth. It is in conformity with the observations of Misra (2001) in chrysanthemum, Jat *et al.* (2007) in marigold, Khosa *et al.* (2011), Bashir *et al*. (2013) in gerbera, Kakade *et al*.

(2009) in China aster, Tank (2010) in rose and Kumar *et al.* (2003) in carnation. Similar findings regarding number of primary branches per plant were obtained by Shah *et al.* (2016) in marigold and Pirzad *et al*. (2013) in anise.

5.1.1.8 Length of primary branches (cm)

Lengths of primary branches were influenced significantly by different doses of zinc, varieties of marigold and their interactions in marigold. The maximum values of lengths of primary branches were observed with the application of 0.5% zinc (29.14 cm) and minimum with control (24.60 cm). In case of interactions, it was observed that maximum lengths of primary branches were found in the zinc 0.7 % × Pusa Basanti Gainda (48.09 cm), while minimum with zinc 0.0 % × Pusa Bahar (16.43 cm), which was significantly at par with zinc 0.0% × Pusa Arpita (16.75 cm), zinc 0.8% × Pusa Bahar (16.93 cm), zinc 0.7% × Pusa Bahar (17.86 cm), zinc 0.5% × Pusa Bahar (18.36 cm) and zinc 1.0% × Pusa Bahar (19.95 cm). This increased in vegetative growth characters due to zinc sulphate might be on account of synthesis of tryptophan, a precursor of indole acetic acid (auxin), which is accelerated by zinc and as such helps the plant to maintain apical dominance Similar findings are obtained Katiyar *et al.* (2012) and Singh *et al.* (2013) in gladiolus.

5.1.2 Effect of different levels of zinc on flowering characters

5.1.2.1 Bud initiation

The data reveals a significant effect on initiation of bud due to various treatments doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc and different varieties of marigold and their interactions. Early bud initiation from the date of transplanting was reported in the 0.5% zinc (97.47 days) treatment, while maximum days taken for bud initiation from the date of transplanting were reported in the control (105.80 days). Early bud initiation was reported in variety Pusa Deep (87.87 days), while maximum days to bud initiation were reported in variety Pusa Arpita (118.33 days). In case of interaction between various treatments doses of zinc and different varieties of marigold, minimum days of bud initiation from the date transplanting were

exhibited by zinc 0.5 % × Pusa Deep (83.67 days), while maximum days of bud initiation from the date of transplanting were reported in zinc 0.0 % × Pusa Arpita (121.00 days). An early flowering with 0.5% each of zinc might be due to enhanced growth and development of plant. Zinc favours the storage of more carbohydrates through photosynthesis. This may be the attributing factor for the positive effectiveness of optimum dose of zinc on reducing juvenile phase of the plant. Similar findings are in line obtained by Similar results are also obtained by Gupta and Kumar (2015) in African marigold and Patokar *et al.* (2017) in marigold.

5.1.2.2 Flower initiation (days)

The significant differences were obtained regarding flower initiation due to various treatments doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc and different varieties of marigold. Early flower initiation were reported in the 0.5% zinc (107.87 days) treatment, while maximum days to flower initiation from the date of transplanting were reported in control (115.73 days). Early flower initiation were noted in variety Pusa Deep (85.00 days), while maximum days to flower initiation from the date of transplanting was reported in variety Pusa Arpita (124.53 days). The interaction between various treatments of zinc and different varieties of marigold were failed to exert any significant effect on days of flower initiation from date of transplanting. This may be the attributing factor for the positive effectiveness of optimum dose of zinc on reducing juvenile phase of the plant. Similar results were also obtained by Jat *et al.* (2007) in marigold, Khosa *et al.* (2011) in gerbera, Tank (2010) in rose and Kumar *et al.* (2003) in carnation.

5.1.2.3 Number of buds per plant

There were a significant differences existing due to various doses of zinc, among different marigold varieties and their studies on interactions regarding number of buds per plant. Maximum number of buds were found and recorded with 0.5% zinc application (59.99), while minimum number of buds were recorded in control (0.0% zinc). The maximum numbers of buds were found in Pusa Deep (72.71) and minimum with variety Pusa Bahar (37.75). Interaction of 0.5% zinc with Pusa Deep (88.78)

resulted in maximum number of buds per plant, while minimum number of buds was chronicled by the treatment combination of 1.0% zinc with Pusa Bahar (32.80). The increase in number of buds per plant might be due to varietal characters of Pusa Deep and application of zinc sulphate causes more accumulation of carbohydrates that helps in induced cell division producing more number of buds and other plant parts (Kendra *et al*., 2013 in chrysanthemum). Similar results were also obtained by Kode *et al*. (2015) in rose.

5.1.2.4 Bud diameter (mm)

Various treatments of zinc and different marigold varieties had a significant effect on bud diameter on different marigold varieties, while interaction effects of zinc on various marigold varieties failed to exert any significant effect on bud diameter. Maximum diameter was reported in 0.5% zinc (13.99 mm) and in variety Pusa Basanti Gainda (16.53 mm), while minimum bud diameter was found with treatment control (11.11 mm) and in variety Pusa Arpita (9.31 mm). This increase in diameter of buds might be due to more accumulation of carbohydrates that helps in induced cell division producing greater diameter of buds and other plant parts. On the other hand it is a varietal character that comes from the parent in Pusa Basanti Gainda having maximum bud diameter among the varieties of marigold. Similar findings are in line with Yonis *et al*. *(*2013) in rose cv. Cardinal and Whisky Mac.

5.1.2.5 Bud length (mm)

The bud length in marigold was significantly influenced due to various doses of zinc, different marigold varieties and their interactions. Maximum bud length in marigold varieties were found with 0.5% zinc (19.02 mm) dose, while minimum with 1.0 % zinc (16.70 mm) concentration. Among diiferent varieties, Pusa Narangi Gainda (19.68 mm) was registered for maximum bud length, while minimum with Pusa Arpita (14.01 mm). In interactions, maximum lengths of buds were noted in zinc 0.5% × Pusa Narangi Gainda (21.78 mm), while minimum with zinc 1.0 % × Pusa Bahar (12.33 mm). This might be due to of carbohydrates that help in induced cell division producing greater diameter of buds and other plant parts and also it is a

characterstics of variety of having maximum bud length in Pusa Narangi Gainda followed by Pusa Basanti Gainda among the varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar and Pusa Narangi Gainda). Similar findings are in line with Yonis *et al (*2013) in rose cv. Cardinal and Whisky Mac.

5.1.2.6 Number of flowers per plant

The Various doses of zinc on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinized and statistically significant effect found on number of flowers. Maximum numbers of flowers were recorded with dose of 0.5% zinc (46.04), while minimum with control (29.77). Pusa Deep has resulted significantly maximum number of flowers (55.27) than other varieties of marigold, while minimum numbers of flowers were observed in variety Pusa Bahar (26.54). Interaction of zinc with dose 0.5% in variety Pusa Deep culminated to maximum number of flowers (72.05) while minimum with control × Pusa Bahar (23.08) treatment combination. Generally Pusa Deep results more number of flowers than other varieties due to its parentage character. The increase in number of flowers might be due to more production of tryptophan which acts as a precursor of auxin. More the production of auxin might help in increase in vegetative growth by suppressing the juvenile phase of plant. This leads to production of more food materials which in turn might have used in more flower production (Muthumanickam, 1999). However, foliar application is more effective in fertilization of various field and floricultural crops (Verma, 2003). The findings are in conformity with the results of Shah *et al*. (2016) in marigold, Kode *et al*. (2015), Younis *et al.* (2013) in rose and Halder *et al*. (2007) in gladiolus.

5.1.2.7 Peduncle length (cm)

The lengths of peduncle were significantly influenced by different doses of zinc applied, varieties of marigold and their treatment interactions with marigold varieties. Maximum length of peduncle was reported by 0.5% zinc treatment (7.85 cm), while minimum with 1.0% zinc (7.01 cm). In case of different varieties of marigold, maximum lengths of peduncle were recorded in Pusa Basanti Gainda (9.39

cm) and Minimum with Pusa Arpita (6.51 cm). Maximum length of peduncle was resulted in control (0.0% zinc) with Pusa Basanti Gainda (10.43 cm) and minimum with 1.0% zinc with Pusa Arpita (5.41 cm). The increased peduncle length might be due to production of increased level of tryptophan which is known as precursor of auxin. The auxin helps in increase in vegetative growth of the plant including peduncle length (Muthumanickam, 1999).

5.1.2.8 Flower diameter (mm)

Significant effects were observed by the different treatment doses of zinc, varieties of marigold and their interactions. Maximum flower diameter was noted with 0.5% zinc (56.76 mm), while minimum with 0.7% zinc (53.44 mm). Maximum flower diameter was exhibited by variety Pusa Basanti Gainda (63.56 mm) which was found significantly highest among all the varieties of marigold. The flowers of variety Pusa Basanti Gainda bear maximum flower diameter than other varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar and Pusa Narangi Gainda) due to its varietal character, while the minimum flower diameter was reported in variety Pusa Arpita (48.64 mm). In case of interactions, maximum flower diameter was observed in 0.5% zinc with Pusa Basanti Gainda (68.03 mm), minimum flower diameter was exhibited by the interaction of 0.0% zinc with Pusa Arpita (43.02 mm). The reason behind increased diameter of flower might be due to varietal effect and the optimum concentration of zinc involved in RNA metabolisim and ribosomal content that leads to stimulate carbohydrate, protein and DNA content. It might help in synthesis of tryptophan which acts as growth promoting substance. The results are in line with the findings of Balakrishanan *et al.* (2007) and Shah *et al*. (2016) in marigold, Saini *et al*. (2015) and Karuppaiah (2014) in chrysanthemum, Pal (2011) in gerbera and Jagtap *et al.* (2012) in rose.

5.1.2.9 Fresh weight of individual flower (g)

Significant effect exhibited by various treatments of zinc, different varieties of marigold and their interactions on fresh weight of individual flower in marigold. Maximum fresh weight of flower was reported in the treatment application of 0.5%

zinc (6.03 g) while minimum with control (4.67 g). Among varieties at full bloom stage, maximum fresh weight of individual flower obtained with Pusa Basanti Gainda (5.95 g), while minimum with Pusa Deep (3.82 g). However, among interactions, maximum fresh weight of individual flower was observed in the interaction 0.5% zinc with Pusa Basanti Gainda (7.68 g), while minimum fresh weight of individual flower was observed in zinc 1.0% × Pusa Deep (3.37 g). $ZnSO_4$ plays a vital role in production of vegetative growth and ultimately encourages the biomass of plant which results in increased fresh weight of plants and thus leads to production of more food material which might have been utilized for better development of size. Similar result was also obtained by Shah *et al*. (2016) in marigold and Patel *et al.* (2017) in tuberose.

5.1.2.10 Dry weight of individual flower (g)

Dry weight of flower was significantly influenced by the various treatments of zinc, varieties of marigold and their interactions. Maximum dry weight of flower was observed in treatment 0.5% zinc (0.74 g) while minimum with control (0.59 g). Among varieties, maximum dry weight of flower was observed in the variety Pusa Basanti Gainda (0.87 g), while minimum with Pusa Arpita (0.46 g). Among interaction treatments, maximum dry weight of flower were reported with the interaction zinc 0.5 % × Pusa Basanti Gainda (1.08 g) while minimum dry weight of flower was reported in zinc 0.0 % × Pusa Arpita (0.40 g). Increased dry weight was due to application of zinc sulphate in production of vegetative growth and ultimately encourages the biomass of plant which results in increased fresh weight of plants and thus leads to production of more food material which might have been utilized for better development of size and weight. Similar results were also obtained by Patel *et al*. (2017) in tuberose.

5.1.2.11 Yield of flowers per plot (Kg)

Significant effects were observed on flower yield per plot due to various treatments of zinc (control, 0.5%, 0.7%, 0.8%, and 1.0%) and varieties of marigold. Maximum yield of flowers per plot were reported in 0.5% zinc (1.62 Kg), while

minimum yield of flowers per plot were observed in control (1.28 Kg). In case of varieties of marigold, the maximum yield of flowers per plot was clearly observed in Pusa Deep (1.75 Kg) and minimum yield of flowers were observed in Pusa Arpita (0.93 Kg). However, interactions between various treatments of zinc and varieties of marigold failed to exhibit any significant effect on yield of flower per plot. The increased in yield of flowers per plot due to application of zinc sulphate might be because of the fact that zinc sulphate increases the vegetative growth and leads to more production of food material, which in turn utilized for better development of buds and flowers which may results in increased number of flowers and flower yield. Similar results were in conformity with finding of Jat *et al.* (2007), Dashora and Verma (2004), Mathew *et al.* (2004) in marigold, Saini (2014), Barman and Pal (1990) in chrysanthemum and Kakade *et al.* (2009) in china aster.

5.1.3 Effect of different levels of zinc on Seed characters

5.1.3.1 Number of seeds per flower

Various doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc on different varieties of marigold (*Tagetes erecta*) have been found statistically significant on number of seeds per flower. Maximum number of seeds per flower was recorded with dose of 0.5% zinc (243.60), while minimum number of seeds per flower was recorded with control (194.80). Among varieties, Pusa Basanti Gainda (256.53) has resulted significantly maximum number of seeds per flower, while minimum number of seeds per flower was observed in Pusa Deep (118.09). In case of interactions of different doses of zinc with different varieties of marigold were failed to strive any significant effect on the number of seeds per flower. Pusa Basanti Gainda because of inherited parental characters bears more number of seeds among the varieties (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, and Pusa Narangi Gainda) This might be due to varietal character on the other hand it might be due to the fact that zinc sulphate increases the vegetative growth and leads to more production of food material, which in turn utilized for better seed yield development and thus, more number of seeds per flower.

5.1.3.2 Weight of seeds per flower (g)

Significant effect was exhibited by various treatment doses of zinc and different varieties of marigold. But the interaction between various treatments of zinc and varieties of marigold were failed to exert any significant effect on weight of seeds per flower. In various treatments of zinc maximum seeds weight per flower was reported in 0.5 % zinc (0.43 g), while minimum with control (0.35 g). Among different varieties of marigold exerting significant effect on maximum seeds weight per flower, Pusa Bahar exhibited maximum seed weight per flower (0.49 g), while Pusa Arpita gave minimum seed weight per flower (0.24 g). The interaction between various treatments of zinc and varieties of marigold were failed to exert any significant effect on weight of seeds per flower. This might be due to the fact that zinc sulphate increases the vegetative growth and leads to more production of food material, which in turn utilized for better seed yield development and weight of seeds per flower.

5.1.3.3 Weight of 100 seeds (g)

Significant effects were exerted by the various treatments of zinc, varieties of marigold and their interactions on weight of 100 seeds. Maximum 100 seed weight was found in the treatment application of 0.5% zinc (0.26 g), while minimum 100 seed weight is observed inn control (0.19 g). Among varieties, maximum 100 seed weight was reported in the variety Pusa Deep (0.26 g), while minimum 100 seed weight was reported in variety Pusa Arpita (0.16 g). In various interactions studies, maximum 100 seed weight was observed in the zinc 0.5 % × Pusa Deep (0.31 g) and minimum with zinc 0.0 % × Pusa Arpita (0.15 g) and zinc 0.7 % × Pusa Arpita (0.15 g). This might be due to the fact that zinc sulphate increases the vegetative growth and leads to more production of food material, which in turn utilized for better seed yield development and biomass.

5.1.3.4 Seed yield per plot

Effect seed yield per plot due to various treatments doses (control, 0.5%, 0.7%, 0.8% and 1.0%) of zinc, varieties of marigold have been found significant.

Maximum seed yield per plot was reported in 0.5% zinc (171.71 g), while minimum with control (107.42 g). Variety Pusa Deep (233.45 g) exhibited maximum seed yield per plot, while minimum seed yield per plot was reported in Pusa Arpita (57.62 g). In case of interactions, maximum seed yield per plot was reported in zinc 0.5 % × Pusa Deep (326.37 g) and minimum seed yield per plot was reported in zinc 0.8 % × Pusa Arpita (43.03 g). This might be due to the fact that zinc sulphate increases the vegetative growth and leads to more production of food material, which in turn utilized for better seed yield development. The increase in seed yield per plot is proportional to the increase in flower yield per plot. The similar findings are in line with increased flower yield proclaimed by Dashora and Verma (2004), Mathew *et al.* (2004) in marigold, Saini (2014) and Kakade *et al.* (2009) in China aster.

5.2 Effects of different levels of pinching on growth, flowering seed yield and post harvest characters in marigold

5.2.1 Effects of different levels of pinching on growth characters

5.2.1.1 Plant height (cm)

Pinching effect on marigold varieties and their interaction studies have been found significant on plant height of plants. Maximum plant heights (47.77 cm) were recorded with no pinching, while a minimum plant height (38.06 cm) was recorded with third pinching. Among the varieties, Pusa Basanti Gainda was recorded maximum plant height (50.30 cm), while minimum was found with variety Pusa Bahar (33.72 cm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum plant height (59.80 cm), whereas the minimum height of plant was observed among the interaction with the treatment combination of third pinching (P_3) × Pusa Bahar (29.39 cm). Plants remained significantly dwarf compared to no pinching might be due to removal of terminal growing part which resulted in inhibition of plant height. Similar result were also obtained by Khan *et al.* (2018), Nain *et al.* (2017), Parhi *et al.* (2016), Sasikumar *et al.* (2015), Rajyalakshmi and Rajashekhar (2014), Sunitha *et al.* (2007) and Srivastava *et al.* (2002) in marigold

5.2.1.2 Stem diameter (mm)

The effect of pinching on different varieties of marigold *(Tagetes erecta)* and their interactions have been found statistically significant on stem diameter. Maximum stem diameter (85.72 mm) was recorded with third pinching (P_3), while minimum with no pinching (10.87 mm). Among the varieties, maximum stem diameter (104.20 mm) was observed in Pusa Arpita, while minimum with variety Pusa Bahar (11.16 mm). Interaction of third pinching (P_3) in variety Pusa Arpita culminated maximum stem diemeter (382.11), while minimum with treatment combination of no pinching (P_0) × Pusa Arpita (9.43 mm). The decrease of plant height is always associated with increase in stem diameter because shorter the height thicker the stem of plant and vice versa. These findings lend support from Khandelwal *et al.* (2003) in African marigold. Similar result was also obtained by Maharnor *et al*. (2011) and Yadav *et al.* (2004) in marigold.

5.2.1.3 Plant spread (cm)

The effect of pinching on different varieties of marigold (Tagetes erecta) and their interactions have been scrutinize and found statistically significant effect on spread of plant. Maximum plant spread (52.79 cm) was recorded with third pinching (P3), while the minimum plant spread was recorded with no pinching (36.13 cm). Among the varieties, maximum plant spread was observed in Pusa Narangi Gainda (51.43 cm), while minimum spread of plant was observed in variety Pusa Bahar (33.94 cm). Interaction of third pinching (P3) in variety Pusa Narangi Gainda culminated maximum plant spread (60.23 cm), whereas the minimum plant spread was observed among the interaction with the treatment combination of no pinching (P0) × Pusa Bahar (29.77 cm). The possible reason for more plant spread under different pinching treatments may be due to cell elongation and pinching reduced the apical growth of stem, which finally results in more number of secondary branches per plant that leads to increase in plant spread. . The findings agree with the views of Kumar *et al.* (2012) and Sheena Nain *et al*. (2017).

5.2.1.4 Number of leaves per plant

The effect of pinching on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinize and found statistically significant effect on number of leaves per plant. Maximum number of leaf was recorded in plants with third pinching (266.76), while minimum number of leaf per plant was recorded with control (97.43). Among varieties, Pusa Deep has resulted significantly maximum number of leaves per plant (317.34), minimum number of leaf per plant was observed in variety Pusa Bahar (119.48). Interaction of third pinching (P3) in variety Pusa Deep culminated maximum number of leaf per plant (434.29), whereas minimum number of leaves per plant among the interactions was recorded with the treatment combination of no pinching (P0) × Pusa Bahar (64.53). The possible reason for higher number of leaves per plant in different pinching may be due to the increase in metabolic activities, photosynthetic activity and increased cell division. The increased number of leaves might be due to translocation of photosynthates to leaf auxiliary buds and positive effect of foliar application of nitrogen which resulted in production of more number of leaves per plant. The findings agree with the views of Singh *et al*. (2015) Seharawat *et al.* (2003) in marigold and Gnyandev *et al*. (2014) in China aster.

5.2.1.5 Leaf length (cm)

Pinching effect on different varieties of marigold *(Tagetes erecta)* and their interactions have been found statistically significant effect on leaf length. Maximum leaf length was recorded with no pinching (20.59 cm), while minimum leaf length was recorded with third pinching (13.76 cm). Among varieties, Pusa Deep has resulted significantly maximum leaf length (20.80 cm), while minimum leaf length was observed in variety Pusa Bahar (11.18 cm). Interaction of no pinching (P_0) in variety Pusa Deep results maximum leaf length (24.64 cm), while minimum with treatment combination of third pinching (P_3) × Pusa Bahar (7.53 cm). Less numbers of leaves were found in no pinching treatments as compared to pinched treatment that resulted in greater availability of energy and food that helped in improving growth which resulted in progression and increased leaf length. Whereas in case of pinched

treatment the energy demand and nutrients for leaves growth also increased with increase in their number which countered effect of leaf length.

5.2.1.6 Leaf width (cm)

The effect of pinching in different marigold varieties and their interactions has been found statistically significant on leaf width. Maximum leaf width was recorded with no pinching (10.53 cm), while minimum leaf width was recorded with third pinching (8.03 cm). Among varieties, Pusa Deep has resulted significantly maximum leaf width (10.45 cm), while minimum leaf width was observed in variety Pusa Bahar (6.58 cm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda resulted in maximum leaf width (11.02 cm) and minimum with treatment combination of third pinching (P_3) × Pusa Bahar (5.13 cm). The width of leaves decreases with higher levels of pinching as pinching increases the number of leaf and also increases demand of nutrient and energy that reduces the leaf width in pinched plan as compared to no pinching plants.

5.2.1.7 Number of primary branches

The effect of pinching on different varieties of marigold *(Tagetes erecta)* and their interactions have been found statistically significant effect on number of primary branches. Maximum number of primary branches was recorded with double pinching (19.75), while minimum number of primary branches was recorded with control (8.50). Among varieties, Pusa Deep has resulted significantly maximum number of primary branches (19.90) while minimum number of primary branches was observed in variety Pusa Bahar (11.51). However, on interaction studies, it was found that Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of primary branches (27.87), while minimum number of primary branches among the interaction was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (7.33). The formation of primary branches per plant was also affected by different levels of pinching. Maximum number of primary branches recorded under pinching at second level might have resulted due to enhanced cell

division, increased cell size as well as higher leaf area and thus greater photosynthesis activity. Similar result was also obtained by Singh *et al.* (2005) in carnation.

5.2.1.8 Length of primary branches (cm)

A significant effect was found on length of primary branches due to the pinching effect on different varieties of marigold and their interactions. Maximum length of primary branch was recorded with no pinching (24.49 cm), while minimum length of primary branch was recorded with third pinching (17.42 cm). Among varieties and interaction studies, maximum length of primary barches was registered with Pusa Arpita (22.66 cm) and no pinching (P_0) in variety Pusa Arpita (28.83 cm), respectively. While minimum was found with Pusa Bahar (16.49 cm) and treatment combination of third pinching (P_3) × Pusa Bahar (14.37 cm), respectively. Similar result was also obtained by Sasikumar *et al.* (2015).

5.2.1.9 Number of secondary branches

The effect of pinching on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinize and found statistically significant effect on number of secondary branches. Maximum number of secondary branches was recorded with third pinching (29.70), while minimum number of secondary branches was recorded with control (5.53). Among varieties, Pusa Deep has resulted significantly maximum number of primary branches (28.78), while minimum number of primary branches was observed in variety Pusa Bahar (11.93). Interaction of third pinching (P3) in variety Pusa Deep culminated maximum number of secondary branches (43.00), while minimum number of secondary branches among the interaction was recorded with the treatment combination of no pinching (P0) × Pusa Basanti Gainda (4.33). When the apical buds were pinched, the lowering in concentration of phytohormone IAA encouraged the lateral buds to grow and produced new shoots and branches which can be relate to the fact that increase in cytokinin overcome apical dominance. Marked increase in number of secondary branches per plant was noticed with every pinching treatment. The possible reason for more number of secondary branches per plant under different pinching treatments may be due to cell elongation, which finally results in more number of secondary

branches per plant. Similar results also have been reported by Singh et al. (2015), Meena et al. (2015) and Shrivastava et al. (2002) in marigold.

5.2.1.10 Length of secondary branches

The data regarding effect of pinching on different varieties of marigold (*Tagetes erecta*) and their interactions have been scrutinize and found statistically significant effect on length of secondary branch per plant. Maximum length of secondary branches were recorded in plants with double pinching (24.49 cm), while minimum length of secondary branches were recorded in plants with third pinching (10.65 cm). Among varieties, Pusa Basanti Gainda has resulted in significantly maximum length of secondary branch (17.76 cm), while minimum length of secondary branches were observed in variety Pusa Bahar (8.81cm). Interaction of plants with double pinching (P_2) in variety Pusa Basanti Gainda culminated maximum length of secondary branch (27.06 cm), while minimum length of secondary branches among the interaction were recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (6.03 cm).

5.2.2 Effects of different levels of pinching on flower characters

5.2.2.1 Number of buds per plant

It was obtained from the result that the effect of pinching on different varieties of marigold and their interactions that results a significant effect on number of flower buds per plant. Maximum number of buds per plant was recorded with double pinching (84.53) while minimum with control (45.38). Among varieties, Pusa Deep has resulted significantly maximum number of buds per plant (178.41) and minimum with Pusa Bahar (24.38). Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of buds per plant (219.33) and minimum with single pinching (P_1) × Pusa Bahar (21.66). The maximum buds per palnt in double pinched plants were recorded primarily due to the presence of highest number of productive stalks per plant along with varietal effect. These results were in agreement with Chavan *et al*. (2004) and Shinde *et al.* (2005) in carnation.

5.2.2.2 Bud length (mm)

A significant effect was exerted on bud length due to various pinching effects on different varieties in marigold. Lengths of buds in no pinching flower plant were found more than in pinched flower plants. Among various pinching levels, maximum bud length was recorded with no pinching (15.50 mm) and among varieties maximum was recorded with Pusa Basanti Gainda (16.14 mm), while minimum with third pinching (11.03 mm) and Pusa Deep (10.28 mm). However, among various interaction studies, no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum bud length (18.26 mm) and minimum with treatment combination of double pinching (P_2) × Pusa Deep (9.51 mm). The increased flower bud length in no pinching plants as compared to pinched plants might be due to lesser number of buds in unpinched plants having more availability of food material and better allocation of energy, while in pinching the photosynthates are diverted and utilized by more number of buds that might leads to decrease in lengths of buds.

5.2.2.3 Bud diameter (mm)

A significant difference on pinching effect between different varieties of marigold and their interactions was found on bud diameter of marigold. Maximum bud diameter was recorded with no pinching (11.09 mm), while minimum with third pinching (7.00 mm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum bud diameter (13.44 mm) and minimum with variety Pusa Arpita (5.36 mm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum bud diameter (15.39 mm) and minimum with third pinching (P_3) × Pusa Deep (3.62 mm). Availability of more food material and better allocation of energy pertaining to lesser numbers of buds with large diameter, which ultimately leads to large diameter of buds in no pinching flower crop also it is varietal character inherited from parent in Pusa Basanti Gainda producing maximum flower diameter among the varieties Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, and Pusa Narangi Gainda. Similar findings regarding large bud diameter in no pinching plants were reported by Badge *et al.* (2015), Sasikumar *et al.* (2015), Mahornar *et al.* (2011) in marigold and Khobragade *et al.* (2012) in china aster and Dalal *et al.* (2006) in carnation.

5.2.2.4 Number of flowers per plant

The effect of pinching on different varieties of marigold *(Tagetes erecta)* and their interactions have been scrutinized and found statistically significant on number of flowers per plant. Maximum number of flowers per plant was recorded with double pinching (75.70) while minimum with control (35.19). Among varieties, Pusa Deep has resulted significantly maximum number of flowers per plant (163.10) which is also a parental effect as compared among all the varieties of marigold (Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar, and Pusa Narangi Gainda), while minimum with variety Pusa Bahar (18.88). Among interaction studies, it was observed that double pinching (P_2) in variety Pusa Deep culminated maximum number of flowers per plant (206.95) while minimum was recorded with single pinching (P_1) × Pusa Bahar (13.00). The increase in number of flowers with pinching may be due to production of more number of primary and secondary branches per plant which ultimately produced more number of flowers per plant. Similar results were reported by Meena *et al.* (2015), Tomar *et al.* (2004), Sehrawat *et al.* (2003), Srivastava *et al*. (2002) in marigold, Grawal *et al.* (2004), Yassin and Pappiah (1990) in chrysanthemum and Gnyandev *et al.* (2014) in China aster.

5.2.2.5 Flower diameter (cm)

The pinching effect on different varieties of marigold and their interactions have been studied and found statistically significant on flower diameter in marigold. Maximum flower diameter was recorded with no pinching (52.89 cm) and minimum flower diameter was recorded with third pinching (46.61 cm). Among varieties of marigold taken for different treatment of pinching, Pusa Basanti Gainda has resulted significantly maximum flower diameter (61.38 cm) and minimum with variety Pusa Arpita (43.41 cm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum flower diameter (63.44 cm) and minimum with treatment combination of third pinching (P_3) × Pusa Arpita (39.86 cm). The reason for increased diameter of the flowers with no pinching might be due to availability of more food material and better allocation of energy pertaining to lesser number of flowers. Similar results were reported by Sasikumar *et al.* (2015), Badge *et al.* (2015),

Mahornar *et al.* (2011) in marigold and Khobragade *et al.* (2012) in China aster, Dalal *et al.* (2006) in carnation and shinde *et al.* (2010) in chrysanthemum.

5.2.2.6 Peduncle length (cm)

Increase in levels of pinching decrease the length of peduncle. A significant effect was obtained due to pinching effect on different varieties of marigold *(Tagetes erecta)* and their interactions on peduncle length of marigold. Maximum peduncle length was recorded with single pinching (8.71 cm) while minimum with third pinching (3.96 cm). Among varieties, Pusa Deep has resulted significantly maximum peduncle length (8.48 cm) and minimum with Pusa Arpita (4.20 cm). Interaction of single pinching (P_1) in variety Pusa Deep results maximum peduncle length (20.40 cm) and minimum with third pinching (P_3) × Pusa Arpita (3.52 cm). It might be due to the reason that decreased length of peduncle of the flowers with no pinching might leads to availability of more food material and better allocation of energy pertaining to more length of peduncle of flowers and greater access to promoted length of peduncle in no pinching marigold. Same finding was reported by Badge *et al*. (2015) in African marigold and Nath *et al.* (2010) in China aster cv. PG White. Similar result was also reported by Mohanty *et al.* (2015).

5.2.2.7 Fresh weight of flower (g)

Pinching effect on different varieties of marigold and their interactions have found significant on fresh weight of flower. Maximum fresh weight of flower was recorded with no pinching (4.68 g), while minimum with third pinching (3.96 g). Among varieties, Pusa Basanti Gainda has resulted significantly maximum fresh weight of flower (5.46 g) and minimum with Pusa Arpita (3.49 g). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda registered for maximum fresh weight of flower (5.91 g), while minimum with third pinching (P_3) × PusaDeep (3.28 g). This might be due to efficient utilization of the biomass for limited number of flowers produced in the unpinched plant, while in pinching the photosynthates are diverted and utilized by more number of flowers that might leads to decrease in fresh weight of

flower. The findings are agree with the views of Mohanty *et al.* (2015), Rathore *et al.* (2011) in marigold, Sailaja *et al*. (2013) and Khobragade *et al.* (2012) in China aster.

5.2.2.8 Dry weight of flower (g)

Pinching effect exerted a significant effect on different varieties of marigold (*Tagetes erecta*) and their interactions on dry weight of flower. Maximum dry weight of flower was recorded with single pinching (1.63 g) while minimum with third pinching (1.49 g). Among varieties, Pusa Basanti Gainda has resulted significantly maximum dry weight of flower (2.10 g) and minimum with Pusa Arpita (1.26 g). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum dry weight of flower (2.36 g), while minimum with treatment combination of no pinching (P_0) × Pusa Arpita (1.05 g). As fresh weight of flower was recorded maximum in no pinching plants, which is obvious that dry weight of the respective flower should be maximum *i.e.* in no pinching (P_0) plants. Similar results are also reported by Rathore *et al.* (2011) in African marigold cv. Pusa Basanti Gainda.

5.2.2.9 Flower yield per plot (g)

The effect of pinching on different varieties of marigold and their interactions have scrutinize exerted a significant effect on flower yield per plot. Maximum flower yield per plot was recorded with double pinching (841.97 g), while minimum flower yield per plot was recorded with no pinching (565.82 g). Among varieties, Pusa Deep has resulted significantly maximum flower yield per plot (1893.33 g) and minimum with Pusa Bahar (275.39 g). Interaction of double pinching (P_2) in variety Pusa Deep results maximum flower yield per plot (2136.21 g), while minimum with single pinching (P_1) × Pusa Bahar (206.89 g). The increase in yield of flowers under pinching treatments may be due to the fact that pinching checked the apical dominance and diverted extra metabolites into the production of more number of flowers. The present findings are in conformity with the report of Sharma *et al*. (2006) and this finding is in agreement with the observation made by Chauhan *et al*. (2016), Prakash *et al*. (2016), Singh *et al.* (2015) in marigold and Dalal *et al.* (2006) in carnation.

5.2.3 Effects of different levels of pinching on seed characters

5.2.3.1 Number of seeds per flower

Different varieties of marigold and their interactions exerted a significant effect on number of seeds per flower. Maximum number of seeds per flower was recorded with no pinching (218.47) while minimum with third pinching (194.80). Among varieties, Pusa Basanti Gainda has resulted significantly maximum number of seeds per flower (269.42) and minimum with Pusa Arpita (143.03). In interaction studies, it was observed that no pinching (P_0) in variety Pusa Basanti Gainda exerted maximum number of seeds per flower (286.10) and minimum with second pinching (P_2) × Pusa Deep (108.27). This might be due to efficient utilization of the biomass for limited number of flowers produced in the unpinched plant. This increase in seed number in no pinching was well attributed to less growth in flower number but with increased diameter which might host more number of seeds individually. Same case has been reported by Mohanty *et al.* (2015), Shinde *et al.* (2014) in marigold and Phetpradap *et al.* (1994) in dahlia.

5.2.3.2 Weight of 100 seeds (g)

Pinching effect exerted a significant effect on different varieties of marigold *(Tagetes erecta)* and their interactions on weight of 100 seeds. Maximum weight of 100 seeds was recorded with single pinching (0.28 g) and minimum with control (0.19 g). Among varieties, Pusa Deep has resulted significantly maximum weight of 100 seeds (0.27 g) and Pusa Narangi Gainda (0.27 g), while minimum with Pusa Arpita (0.17 g). Interaction of single pinching (P_1) in variety Pusa Deep resulted in maximum weight of 100 seeds (0.33 g) while minimum with treatment combination of control (P_0) × Pusa Arpita (0.15 g). The higher 100 seed weight noticed in no pinching treatments that might be attributed to greater contribution of available photo-assimilate enabling enhancement in better assimilation and accumulation of more dry matter yielding better seed development. These finding are in agreement with the views of Bhat and Shephered (2007), Tomar *et al.* (2004) in marigold and Phetpradap *et al.* (1994) in dahlia.

5.2.3.3 Weight of seeds per flower (g)

The effects of pinching on marigold varieties and their interactions have been studied and exerted a significant effect on weight of seeds per flower. Maximum weight of seeds per flower was recorded with no pinching (0.29 g), while minimum with third pinching (0.21 g). Among varieties, Pusa Deep has resulted significantly maximum weight of seeds per flower (0.30 g) while minimum was found with Pusa Arpita (0.21 g) in marigold. Among interaction studies, maximum weight of seeds per flower was registered with no pinching (P0) in variety Pusa Deep (0.35 g) while minimum was exerted with both third pinching (P3) × Pusa Arpita (0.18 g) and double pinching (P2) × Pusa Arpita (0.18 g) treatment combinations. It might be due to reduction in flower number and available of more biomass stimulating increase in size of flower holding bigger seed and subsequently increase in their weight as compare to pinched one.

5.2.3.4 Seed yield per plot (g)

A significant effect was registered with different varieties of marigold and their interactions on seed yield per plot due to the effect of pinching. Maximum seed yield per plot was recorded with double pinching (57.44 g) while minimum with control (39.74 g). Among varieties, Pusa Deep has resulted significantly maximum seed yield per plot (151.53 g) and minimum was recorded with Pusa Bahar (13.53 g). Interaction of double pinching (P_2) in variety Pusa Deep result maximum seed yield per plot (175.54 g) and minimum was found with treatment combination of control (P0) × Pusa Bahar (11.35 g). This might be due to production of more number of primary branches and flower by influence of pinching. These finding are in agreement with the views of Bhat and Shephered (2007), Tomar *et al*. (2004) in marigold and Phetpradap *et al*. (1994) in dahlia.

Chapter VI

SUMMARY AND CONCLUSION

The field and laboratory experiments were carried out with the objective of studying the effect of different levels of zinc and pinching on growth, flowering, seed yield and post-harvest characters in marigold cv. Pusa Arpita, Pusa Deep, Pusa Basanti Gainda, Pusa Bahar and Pusa Narangi Gainda.

The field experiment was conducted at Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (India) during winter 2018-19. The experiment was laid out in Randomized Block Design with three replications. The treatment of zinc comprised 4 levels (0.5%, 0.7%, 0.8% and 01.0%) and control, while pinching includes 4 levels (no pinching, single pinching, double pinching and third pinching). The salient findings of the present investigation are summarized as below.

6.1 Experiment no. 1: Effect of different levels of zinc in different varieties of marigold

6.1.1 Growth parameters

1. Application of zinc @ of 0.5% resulted in maximum plant height (43.50 cm), while minimum plant height was recorded in control (39.60 cm). Among the different varieties of marigold maximum plant height was recorded in variety Pusa Basanti Gainda (55.20 cm) and the minimum plant height was found in Pusa Deep (25.20 cm). Treatment combination of zinc 0.5% × Pusa Basanti Gainda resulted the maximum plant height (70.43 cm), while minimum plant height was reported in zinc 0.5% × Pusa Deep (24.08 cm).

2. Maximum stem diameter was recorded with zinc treatment of 0.5% (11.16 mm), while minimum stem diameter was recorded in control (9.33 mm). Whereas, variety Pusa Narangi Gainda results maximum stem diameter (11.28 mm), while minimum stem diameter was noted down in Pusa Arpita (9.14 mm). Interaction of 0.5% zinc with Pusa basanti gainda resulted maximum

stem diameter (13.14 mm), whereas minimum stem diameter was noted down in interaction zinc 0.8% × Pusa Arpita (8.2 mm).

3. Highest value of plant spread was reported in treatment 0.5% zinc (44.60 cm), while minimum plant spread was established in treatment 0.7% zinc (38.89 cm). Among the different varieties of marigold the maximum plant spread was observed in variety Pusa Deep (49.30 cm) and the minimum spread of plant was recorded in Pusa Bahar (28.37 cm). However, interaction effect of zinc doses with various varieties in marigold failed to exert any significant effect on spread of plant.

4. The maximum number of leaves per plant was recorded in the treatment 0.5% zinc (113.86), while the minimum number of leaves per plant was recorded in the control (97.89). Whereas, maximum number of leaves per plant was observed by variety Pusa Narangi Gainda (188.92), while the minimum number of leaves per plant was resulted by variety Pusa Arpita (67.11). In interactions, 1.0% zinc with Pusa Narangi Gainda gave maximum number of leaves per plant (229.87), whereas the minimum number of leaves per plant was resulted in the zinc 0.8% × Pusa Bahar (57.93).

5. Treatment of zinc @ 0.5% significantly influenced the leaf length and gave the maximum leaf length (20.09 cm), while 1.0% zinc gave the minimum length of the leaf (18.04 cm). Among varieties, Pusa Deep gave the maximum leaf length (23.71cm), while the minimum length of the leaf was recorded by Pusa Bahar (17.06 cm). Among interactions, combination of 0.7% zinc with Pusa Deep (26.09 cm) gave maximum leaf length, while minimum leaf length was recorded in zinc 1.0% × Pusa Bahar (14.06 cm).

6. Treatments of zinc @ 0.5% show the maximum leaf width (10.55 cm), while the minimum leaf width was recorded in 1.0% zinc (9.68 cm). Among the different varieties of marigold maximum leaf width was found in variety Pusa Deep (12.11 cm), while minimum leaf width was recorded in variety Pusa Basanti Gainda (9.05 cm). Interaction of 0.5% zinc with Pusa Deep gave the

maximum leaf width (13.22 cm), while minimum leaf width was reported in the interaction zinc 1.0% × Pusa Basanti Gainda (7.46 cm).

7. Significantly higher number of primary branches per plant was recorded under the treatment of 0.5% zinc (13.11), while minimum number of primary branches per plant was recorded with control (10.99). The highest number of primary branches per plant was observed in variety Pusa Deep (13.31), while the minimum number of primary branches per plant was noted in Pusa Basanti Gainda (10.71). The interaction of 0.5% zinc with Pusa Narangi Gainda gave highest number of primary branches per plant (15.40), while among the different interactions minimum number of primary branches per plant was noted in zinc 0.0 % × Pusa Arpita (6.67).

8. Maximum length of primary branch was observed by the application of 0.5% zinc (29.14 cm), while the minimum length of primary branch was observed in control (24.60 cm). In case of interactions, it was observed that maximum length of primary branch was found in interaction zinc 0.7% × Pusa Basanti Gainda (48.09 cm) and the minimum length of primary branch among the interactions was observed in zinc 0.0% × Pusa Bahar (16.43 cm).

Flower parameters

1. Minimum days to bud initiation were reported in the 0.5% zinc (97.47 days), while maximum days of bud initiation were reported in the control (105.80 days). In different varieties of marigold minimum days of bud initiation were noted in variety Pusa Deep (87.87 days). However, maximum days of bud initiation were reported in variety Pusa Arpita (118.33 days). In case of interaction minimum days to bud initiation were exhibited by zinc 0.5% × Pusa Deep (83.67 days), while maximum days of bud initiation from the date of transplanting was reported in zinc 0.0 % × Pusa Arpita (121.00 days).

2. Minimum days to flower initiation from the date of transplanting were reported in the 0.5% zinc (107.87 days) treatment, while maximum days to

flower initiation were reported in the control (115.73 days). However , among different varieties minimum days of flower initiation from the date of transplanting was noted in variety Pusa Deep (85.00 days), while maximum days to flower initiation were reported in variety Pusa Arpita (124.53 days). The interaction between various treatments of zinc and different varieties of marigold were failed to exert any significant effect on days to flower initiation.

3. Regarding the data on number of flowers per plant maximum numbers of flowers were recorded with 0.5% zinc (46.04) followed by 0.8% zinc (36.18) and 0.7% zinc (35.77), while minimum numbers of flowers per plant were recorded with control (29.77). Among varieties, Pusa Deep has resulted significantly maximum number of flowers (55.27), while minimum number of flowers per plant were observed in variety Pusa Bahar (26.54) in marigold. Interaction of zinc with dose 0.5% in variety Pusa Deep culminated maximum number of flowers (72.05) and minimum numbers of flowers per plant among the interaction were recorded with the treatment combination of control × Pusa Bahar (23.08).

4. Maximum numbers of buds were found in treatment 0.5% zinc (59.99), while the minimum numbers of buds were recorded in control (0.0% zinc). In varieties, maximum numbers of buds were found in Pusa Deep (72.71), while minimum numbers of buds were resulted in variety Pusa Bahar (37.75). However, in interaction maximum numbers of buds were resulted in the interaction of 0.5% zinc with Pusa Deep (88.78), while minimum numbers of buds were chronicled by the treatment combination of 1.0% zinc with Pusa Bahar (32.80).

5. Maximum flower diameter was noted in 0.5% zinc (56.76 mm) and minimum diameter of flower was reported in treatment 0.7% zinc (53.44 mm). Among the varieties, maximum flower diameter was exhibited by variety Pusa Basanti Gainda (63.56 mm), whereas, minimum flower diameter was reported by variety Pusa Arpita (48.64 mm). In in case of interaction, maximum flower

diameter was observed in interaction between 0.5% zinc with Pusa Basanti Gainda (68.03 mm), while minimum flower diameter was exhibited by the interaction of 0.0% zinc with Pusa Arpita (43.02 mm).

6. Maximum length of peduncle was reported by 0.5% zinc treatment (7.85 cm) and the minimum peduncle length was resulted by 1.0% zinc (7.01 cm). In case of different varieties of marigold, maximum peduncle length was recorded in Pusa Basanti Gainda (9.39 cm) and minimum peduncle length was observed in Pusa Arpita (6.51 cm). In interactions, maximum length of peduncle was resulted in control (0.0% zinc) with Pusa Basanti Gainda (10.43 cm), while the minimum length of peduncle was recorded in 1.0% zinc with Pusa Arpita (5.41 cm).

7. Maximum bud diameter was reported in 0.5% zinc (13.99 mm), while minimum bud diameter was found in control (11.11 mm). Variety Pusa Basanti Gainda (16.53 mm) exhibited maximum diameter of bud and minimum bud diameter was reported in Pusa Arpita (9.31 mm). Interaction failed to give any effect.

8. Among various treatments, zinc @ 0.5% (19.02 mm) treatment resulted in the maximum length of bud in marigold, while minimum bud length was reported in 1.0% zinc (16.06 mm). Among different varieties of marigold, significantly maximum length of bud was observed with variety Pusa Narangi Gainda (19.68 mm), while the minimum length of bud was reported by the variety Pusa Arpita (14.01 mm). Among interactions, maximum length of bud was noted in zinc 0.5% × Pusa Narangi Gainda (21.78 mm), while minimum length of bud was observed in zinc 1.0% × Pusa Bahar (12.33 mm).

9. Maximum fresh weight of flower was reported in the treatment of 0.5% zinc (6.03 g), while minimum fresh weight of flower was observed in control (4.67 g). variety Pusa Basanti Gainda reported maximum fresh weight of flower (5.95 g), while minimum fresh weight of flower was reported in Pusa Deep (3.82 g). In the interaction, maximum fresh weight of flower was observed in

the interaction 0.5% zinc with Pusa Basanti Gainda (7.68 g) and minimum fresh weight of flower was observed in zinc 1.0 % × Pusa Deep (3.37 g).

10. Maximum dry weights of flowers were observed in treatment 0.5% zinc (0.74 g), minimum dry weights of flowers were observed in the control (0.59 g). Among different varieties of marigold, maximum dry weights of flowers were observed in the variety Pusa Basanti Gainda (0.87 g), while minimum dry weight of flower was observed in variety Puas Arpita (0.46 g). Among interactions maximum dry weight of flower was reported in interaction zinc 0.5% × Pusa Basanti Gainda (1.08 g) and minimum dry weights of flowers were reported in zinc 0.0% × Pusa Arpita (0.40 g).

11. Maximum yield of flower per plot was reported in 0.5% zinc (1.62 Kg), while minimum flowers yield was observed in control (1.28 Kg). In case of varieties, the maximum yield of flowers per plot was clearly observed in Pusa Deep (1.75 Kg) and minimum yield of flowers was observed in Pusa Arpita (0.93 Kg).

Seed parameter

1. Maximum number of seeds per flower was recorded with dose of 0.5% zinc (243.60) and minimum number of seeds per flower was recorded with control (194.80). Among varieties, Pusa Basanti Gainda (256.53) has resulted significantly maximum number of seeds per flower, while minimum number of seeds per flower was observed in Pusa Deep (118.09).

2. In various treatments of zinc, maximum seed weight per flower was reported in 0.5% zinc (0.43 g) and minimum weight of seeds per flower was reported in control (0.35 g). The interaction between various treatments of zinc and varieties of marigold were failed to exert any significant effect on weight of seeds per flower.

3. Maximum 100 seed weight was found in the treatment application of 0.5% zinc (0.26 g), while minimum 100 seed weight is observed inn control (0.19

g). Maximum 100 seed weight was reported in the variety Pusa Deep (0.26 g), while minimum 100 seed weight was reported in variety Pusa Arpita (0.16 g). In various interactions, maximum 100 seed weight was observed in the zinc 0.5% × Pusa Deep (0.31 g) and minimum 100 seed weight was observed in the interaction zinc 0.0% × Pusa Arpita, zinc 0.7% × Pusa Arpita (0.15 g).

4. Maximum seed yield per plot was reported in 0.5% zinc (171.71 g), while minimum seed yield per plot was found in control (107.42 g). Whereas, variety Pusa Deep (233.45 g) exhibited maximum seed yield per plot which was highly significant to other varieties, while minimum seed yield per plot was reported in Pusa Arpita (57.62 g). Among the interactions, maximum seed yield per plot was reported in zinc 0.5 % × Pusa Deep (326.37 g) and minimum seed yield per plot was reported in zinc 0.8 % × Pusa Arpita (43.03 g).

6.2 Experiment no. 2: Effect of different levels of pinching in different varieties of marigold

6.2.1 Growth parameters

1. Maximum plant height (47.77 cm) was recorded with no pinching which was found to be superior among all pinching while the minimum plant height (38.06 cm) was recorded with third pinching. Among the varieties, Pusa Basanti Gainda recorded maximum plant height (50.30 cm), while minimum plant height (33.72 cm) was observed in variety Pusa Bahar. Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum plant height (59.80 cm), whereas the minimum height of plant was observed among the interaction with the treatment combination of third pinching (P_3) × Pusa Bahar (29.39 cm).

2. Maximum stem diameter (85.72 mm) was recorded with third pinching (P_3), while the minimum stem diameter (10.87 mm) was recorded with no pinching. Among the varieties, maximum stem diameter (104.20 mm) was observed in Pusa Arpita, while minimum stem diameter (11.16 mm) was observed in

variety Pusa Bahar. Interaction of third pinching (P_3) in variety Pusa Arpita culminated maximum stem diemeter (382.11), whereas the minimum stem diameter was observed among the interaction with the treatment combination of no pinching (P_0) × Pusa Arpita (9.43 mm).

3. Maximum plant spread (52.79 cm) was recorded with third pinching (P_3), while the minimum plant spread was recorded with no pinching (36.13 cm). Among the varieties, maximum plant spread was observed in Pusa Narangi Gainda (51.43 cm), while minimum spread of plant was observed in variety Pusa Bahar (33.94 cm). Interaction of third pinching (P_3) in variety Pusa Narangi Gainda culminated maximum plant spread (60.23 cm), whereas the minimum plant spread was observed among the interaction with the treatment combination of no pinching (P_0) × Pusa Bahar (29.77 cm).

4. Maximum number of leaves per plant (266.76) was recorded in plants with third pinching (P_3), while minimum number of leaves per plant was recorded with control (97.43). Among varieties, Pusa Deep has resulted significantly maximum number of leaves per plant (317.34), while minimum number of leaves per plant was observed in variety Pusa Bahar (119.48). Interaction of third pinching (P_3) in variety Pusa Deep culminated maximum number of leaves per plant (434.29), whereas minimum number of leaves per plant among the interactions was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (64.53).

5. Maximum leaf length was recorded with no pinching (20.59 cm), while minimum leaf length was recorded with third pinching (13.76 cm). Among varieties, Pusa Deep has resulted significantly maximum leaf length (20.80 cm), while minimum leaf length was observed in variety Pusa Bahar (11.18 cm). In case of interaction, interaction of no pinching (P_0) in variety Pusa Deep has resulted maximum leaf length (24.64 cm), while minimum leaf length among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Bahar (7.53 cm).

6. Maximum leaf width was recorded with no pinching (10.53 cm), while minimum leaf width was recorded with third pinching (8.03 cm). Among varieties, Pusa Deep has resulted significantly maximum leaf width (10.45 cm), while minimum leaf width was observed in variety Pusa Bahar (6.58 cm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda has resulted maximum leaf width (11.02 cm), Minimum leaf width among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Bahar (5.13 cm).

7. Maximum number of primary branches per plant was recorded with double pinching (19.75), while minimum number of primary branches per plant was recorded with control (8.50). Among varieties, Pusa Deep has resulted significantly maximum number of primary branches per plant (19.90), while minimum number of primary branches per plant was observed in variety Pusa Bahar (11.51). Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of primary branches per plant (27.87), while minimum number of primary branches per plant among the interaction was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (7.33).

8. Maximum length of primary branches were recorded with no pinching (24.49 cm), while minimum length of primary branches were recorded with third pinching (17.42 cm). Among varieties, Pusa Arpita has resulted significantly maximum length of primary branches (22.66 cm), while minimum length of primary branches were observed in variety Pusa Bahar (16.49 cm). Interaction of no pinching (P_0) in variety Pusa Arpita culminated maximum length of primary branches (28.83 cm), whereas minimum length of primary branches among the interaction were recorded with the treatment combination of third pinching (P_3) × Pusa Bahar (14.37 cm).

9. Maximum number of secondary branches per plant were recorded with third pinching (29.70), while minimum number of secondary branches per plant were recorded with control (5.53). Among varieties, Pusa Deep has resulted

significantly maximum number of secondary branches (28.78), while minimum number of secondary branches per plant were observed in variety Pusa Bahar (11.93). Interaction of third pinching (P3) in variety Pusa Deep culminated maximum number of secondary branches per plant (43.00), whereas minimum numbers of secondary branches per plant among the interaction were recorded with the treatment combination of no pinching (P_0) × Pusa Basanti Gainda (4.33).

10. Maximum length of secondary branches were recorded in plants with double pinching (24.49 cm), while minimum length of secondary branches were recorded in plants with third pinching (10.65 cm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum length of secondary branches (17.76 cm), while minimum length of secondary branches were observed in variety Pusa Bahar (8.81cm).Interaction of plants with double pinching (P_2) in variety Pusa Basanti Gainda culminated maximum length of secondary branches (27.06 cm), while minimum length of secondary branches among the interaction was recorded with the treatment combination of no pinching (P_0) × Pusa Bahar (6.03 cm).

6.2.2 Flower parameters

1. Maximum number of flowers per plant were recorded with double pinching (75.70), while minimum number of flowers per plant were recorded with control (35.19). Among varieties, Pusa Deep has resulted significantly maximum number of flowers per plant (163.10), and minimum number of flowers per plant were observed in variety Pusa Bahar (18.88). Interaction of double pinching (P_2) in variety Pusa Deep culminated maximum number of flowers per plant (206.95) and minimum number of flowers per plant among the interaction was recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (13.00).

2. Maximum number of buds per plant were recorded with double pinching (84.53), while minimum number of buds per plant were recorded with control

(45.38). Among varieties, Pusa Deep has resulted significantly maximum number of buds per plant (178.41), while minimum number of buds per plant was observed in variety Pusa Bahar (24.38). Interaction of double pinching (P_2) with variety Pusa Deep culminated maximum number of buds per plant (219.33), whereas, minimum numbers of buds per plant among the interaction were recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (21.66).

3. Maximum bud length was recorded with no pinching (15.50 mm), while minimum bud length was recorded with third pinching (11.03 mm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum bud length (16.14 mm), while minimum bud length was observed in variety Pusa Deep (10.28 mm).). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum bud length (18.26 mm), whereas minimum bud length among the interaction was recorded with the treatment combination of double pinching (P_2) × Pusa Deep (9.51 mm).

4. Maximum bud diameter was recorded with no pinching (11.09 mm), while minimum bud diameter was recorded with third pinching (7.00 mm). Among varieties, Pusa Basanti Gainda has resulted significantly maximum bud diameter (13.44 mm), while minimum bud diameter was observed in variety Pusa Arpita (5.36 mm). Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum bud diameter (15.39 mm), whereas minimum bud diameter among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Deep (3.62 mm).

5. Maximum flower diameter was recorded with no pinching (52.89 mm), while the minimum flower diameter was recorded with third pinching (46.61 mm). Among varieties of marigold taken for different treatment of pinching, Pusa Basanti Gainda has resulted significantly maximum flower diameter (61.38 mm), while minimum flower diameter was observed in variety Pusa Arpita (43.41 mm). Interaction of no pinching (P_0) in variety Pusa Basanti Gainda culminated maximum flower diameter (63.44 mm), while minimum flower

diameter among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Arpita (39.86 mm).

6. Maximum peduncle length was recorded with single pinching (8.71 cm), while minimum peduncle length was recorded with third pinching (3.96 cm). Among varieties, Pusa Deep has resulted significantly maximum peduncle length (8.48 cm), while minimum peduncle length was observed in variety Pusa Arpita (4.20 cm). Interaction of single pinching (P_1) with variety Pusa Deep culminated maximum peduncle length (20.40 cm), whereas minimum peduncle length among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Arpita (3.52 cm).

7. Maximum fresh weight of flower was recorded with no pinching (4.68 g) followed by single pinching (4.48 g), while minimum fresh weight of flower was recorded with third pinching (3.96 g). Among varieties, Pusa Basanti Gainda has resulted significantly maximum fresh weight of flower (5.46 g) and minimum fresh weight of flower was observed in variety Pusa Arpita (3.49 g). Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum fresh weight of flower (5.91 g), while minimum fresh weight of flower among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Deep (3.28 g).

8. Maximum dry weight of flower was recorded with single pinching (1.63 g), while minimum dry weight of flower was recorded with third pinching (1.49 g). Among varieties, Pusa Basanti Gainda has resulted significantly maximum dry weight of flower (2.10 g), while minimum dry weight of flower was observed in variety Pusa Arpita (1.26 g). Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum dry weight of flower (2.36 g), whereas minimum dry weight of flower among the interaction was recorded with the treatment combination of no pinching (P_0) × Pusa Arpita (1.05 g).

9. Maximum flower yield per plot was recorded with double pinching (841.97 g), while minimum flower yield per plot was recorded with control (565.82 g). Among varieties, Pusa Deep has resulted significantly maximum flower yield per plot (1893.33 g), while minimum flower yield per plot was observed in variety Pusa Bahar (275.39 g). Interaction of double pinching (P_2) with variety Pusa Deep resulted maximum flower yield per plot (2136.21 g), Minimum flower yield per plot among the interaction was recorded with the treatment combination of single pinching (P_1) × Pusa Bahar (206.89 g).

6.2.2 Seed parameters

1. Maximum number of seeds per flower were recorded with no pinching (218.47), while minimum number of seeds per flower were recorded with third pinching (194.80). Among varieties, Pusa Basanti Gainda has resulted significantly maximum number of seeds per flower (269.42) and minimum number of seeds per flower were observed in variety Pusa Arpita (143.03). Interaction of no pinching (P_0) with variety Pusa Basanti Gainda culminated maximum number of seeds per flower (286.10), whereas minimum number of seeds per flower among the interaction was recorded with the treatment combination of double pinching (P_2) × Pusa Deep (108.27).

2. Maximum weight of 100 seeds was recorded with single pinching (0.28 g) and minimum weight of 100 seeds was recorded with control (0.19 g). Among varieties, Pusa Deep has resulted significantly maximum weight of 100 seeds (0.27 g), while minimum weight of 100 seeds was observed in variety Pusa Arpita (0.17 g). Interaction of single pinching (P_1) with variety Pusa Deep has resulted maximum weight of 100 seeds (0.33 g), while minimum weights of 100 seeds among the interaction was recorded with the treatment combination of control (P_0) × Pusa Arpita (0.15 g).

3. Maximum weight of seeds per flower was recorded with no pinching (0.29 g), while minimum weight of seeds per flower was recorded with third pinching (0.21 g). Among varieties, Pusa Deep has resulted significantly maximum

weight of seeds per flower (0.30 g), while minimum weight of seeds per flower was observed in variety Pusa Arpita (0.21 g) in marigold. Interaction of no pinching (P_0) with variety Pusa Deep culminated maximum weight of seeds per flower (0.35 g), whereas minimum weight of seeds per flower among the interaction was recorded with the treatment combination of third pinching (P_3) × Pusa Arpita (0.18 g).

4. Maximum seed yield per plot was recorded with double pinching (57.44 g), while minimum seed yield per plot was recorded with control (39.74 g). Among varieties, Pusa Deep has resulted significantly maximum seed yield per plot (151.53 g), while minimum seed yield per plot was observed in variety Pusa Bahar (13.53 g). Interaction of double pinching (P_2) in variety Pusa Deep has resulted maximum seed yield per plot (175.54 g), whereas minimum seed yield per plot among the interaction was recorded with the treatment combination of control (P_0) × Pusa Bahar (11.35 g).

Conclusion

On the basis of findings summarized above it may be concluded that foliar application of $ZnSO_4$ at 0.5% was found to be best treatment and beneficial to improve plant growth (plant height, spread, no. of primary branches and length, leaf length and width and stem diameter), flowering (number of flower/plant, flower diameter, early flowering), seed yield (number of seeds/plant, seed yield/flower) and post-harvest characters (fresh and dry weight matter) treatment of 0.5% $ZnSO_4$ found most suitable with variety Pusa Deep than other varieties (Pusa Arpita, Pusa Basanti Gainda,Pusa Bahar and Pusa Narangi Gainda).

However, in case of pinching the third pinching (P_3) treatment recorded higher number of leaves (266.76), plant spread (52.79 cm) and secondary branches per plant (29.70), while double pinching (P_2) reported more number of primary (19.75) higher number of flowers per plant (75.70) and yield of flower per plot (0.841 Kg) and hence, commercially suitable. Among the varieties Pusa Deep was most suitable variety for pinching followed by Pusa Narangi Gainda.

Spraying of $ZnSO_4$ at 0.5% and pinching significantly increased various growth parameters and improved flowering, flower and seed yield. Further it is mentioned that above conclusion are solely based on result of one year experimentation. Therefore, it is suggested to check the result to establish its validity.

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