

Phytomorphology of *Callistephus chinensis* as influenced by differential planting geometry, pinching and compound nutrient sprays.

Abstract

Vegetative growth of China aster (*Callistephus chinensis* (L.) NEES) cv. Powder Puff as influenced by pinching, planting density and nutrient sprays was evaluated in a biannual (2016 and 2017) field experiment and the data was presented in pooled form. The experiment comprised of two levels of pinching (P_0 = no pinching, P_1 = pinching), 3 planting densities (30 plants m^{-2} , 36 plants m^{-2} , 42 plants m^{-2}) and three levels of commercial nutrient sprays (S_1 = 3 sprays, S_2 = 4 sprays and S_3 = 5 sprays), constituting a total of 18 treatment combinations replicated thrice in Randomized Complete Block Design (RCBD). The elucidation of analysed data indicated that pinching at visible bud stage, significantly improves plant spread (37.73 cm), leaf area (5883.25 cm^2), Leaf Area Index (LAI) (21.15), chlorophyll content (60.63), number of primary (16.64) and secondary branches (23.19). Increasing planting density increased plant height (81.26 cm), LAI (23.63). On the other hand wider planting density significantly improved, plant spread (35.61 cm), leaf area (5779.45 cm^2), leaf chlorophyll content (59.85), number of primary (16.12) and secondary branches (22.45). Four (S_2) and five (S_3) sprays of CalMax[®] Gold, significantly improved plant height (79.95 cm) plant spread (33.22 cm, leaf area, LAI, number of primary/secondary branches and chlorophyll content. Pinching results in tangible reduction of plant height, but improves the net photoassimilation and overall vigour, architecture and growth of plants. Wider planting density is advantageous in improving the overall growth of China aster. Application of 4 and 5 nutrient sprays are beneficial in improving the vegetative growth of China aster.

Keywords: aster, chlorophyll, density, pinching, sprays, growth,

Introduction

Globally China aster (*Callistephus chinensis* L. Nees) is considered as one of the important commercial flower grown throughout the year. It belongs to family asteraceae and genus callistephus having single species *Callistephus* having chromosome number $2n=18$ (Li and Zhang, 2004). Though it is originally from Japan and China, this monotypic genus has undergone many changes in form, size and colour to adapt itself to various environments. The

genomic name of China aster *Callistephus* was derived from two Greek words “Kalistos” means most beautiful and “Stephus” means a crown, referring to the large and colourful flower heads (Maheta *et al.* 2016). In most of the flower crops, seed yield is mainly dependent on number of flower bearing branches which could be manipulated by arresting vertical growth of plants and encouraging side shoot by means of apical bud pinching. But, studies on influence of pinching in China aster on seed yield and quality are meagre. Plant population per unit area, pinching and nutrient sprays has a significant bearing on vegetative and final seed yield in flowering annuals. Several workers (Ozer, 2004) in different annuals have reported improved vegetative growth through micronutrient sprays thus resulting in enhanced returns per unit area. Numerous studies (Golcz *et al.*, 2006; Dzida and Jarosz, 2006; Biesiada and Kuś, 2010) have shown that nutrient sprays results in a significant increase in quantity and quality of herbal plant yields.

Thus keeping in view the above facts present investigation was proposed to be undertaken with objective. To study the influence of pinching, planting density and nutrient sprays on vegetative attributes of China aster cv. Powder puff.

Material and methods

The present investigation was carried out in the Experimental field of Department of Floriculture & Landscape Architecture, SKUAST- Kashmir, Srinagar. The experiment involved 2 levels of pinching, 3 levels of planting density and 3 levels of sprays, comprising a total of 18 treatment combinations. The experiment entitled was conducted during the years 2016 and 2017 at and the data was presented in pooled form. The experiment was laid out in Randomized Complete Block Design (RCBD) with eighteen treatment combinations replicated three times. Commercial nutrient sprays of CalMax gold were used during the course of investigation.

The details of different treatments involved in the experiment are as follows:

Pinching (02)	Notation	Planting density (03)	Notation	Sprays (03) *	Notation
No pinching	P ₀	30 plants m ⁻²	D ₁	3 sprays	S ₁
Pinching	P ₁	36 plants m ⁻²	D ₂	4 sprays	S ₂
		42 plants m ⁻²	D ₃	5 sprays	S ₃
Total No. of treatments = 18					

58 *all sprays (CalMax gold) were commenced from 20 days after transplanting within an interval of 10 days

59 **Observations recorded.**

60 **Plant height (cm)**

61 The height of plant was measured from ground level to the tip of plant at 50, 75 and
62 100 days after transplanting. The average height (cm) of plant was worked out. The height
63 (cm) was measured with the help of meter scale.

64 **Plant spread (cm)**

65 The plant spread in North-South and East-West directions was recorded in centimetre
66 at 50, 75 and 100 DAT and the average was figured out.

67 **Leaf area (cm²)**

68 The leaf area plant⁻¹ was taken at 50, 75 and 100 DAT with the help of leaf area meter
69 in cm².

70 A non-portable type of leaf area meter (L.A 211, Systronics) was used. The leaves
71 were removed from the stem at the pre- designated time. The leaf area meter was calibrated
72 before use and was set between the ranges of 0-100. The leaves were carefully placed on the
73 stage and were covered with the glass plate, and the recordings were noted down. The sum of
74 leaf area of all the leaves was taken to get the total leaf area plant⁻¹.

75 **Leaf area index (LAI)**

76 Leaf area was calculated with the use of following equation

77 LAI= Leaf Area÷Ground Area

78 **Chlorophyll content**

79 The leaf chlorophyll content at 50, 75 and 100 DAT was estimated with the help of
80 SPAD meter. After each reading the average was worked out.

81 **Number of primary branches per plant**

82 The number of primary branches per plant was counted and reported as mean
83 performance from 50 DAT at 25 days interval. The primary branches were those, which were
84 emerging from the main axis of the plant.

85 (S.F 400, Capacity 750g×0.1 g).

86 **Number of secondary branches/plant**

87 The total number of secondary branches/plant was counted and reported on mean
88 basis at 75 and 100DAT. Secondary branch were emerging from the primary branch.

89 **Results and Discussion**

90 **Plant height**

91 Between pinching and no pinching treatments (Table 1), non pinched plants (P_0)
92 recorded significantly more plant height at 50, 75 DAT and at 100 DAT (40.16, 54.57 and
93 81.17 cm, respectively) compared to pinched plants. It might be due to the reason of apical
94 dominance in case of unpinched plants and no pinched plant grew upto the original height
95 without reduction as supported with the findings of Sehrawat *et al.* (2003) and Tomar *et al.*
96 (2004) in African marigold, Gyandev (2006) and Khobragade *et al.*, 2012 in China aster.

97 It was observed that the magnitude of plant height was maximum at the closer spacing
98 of (D_3) and decreased gradually as the spacing increased in all the observation recorded at 75
99 and 100 days after transplanting. The maximum plant height was 81.26 cm in a spacing of D_3
100 (100 DAT). The increased plant height in closer spacing might be due to intra plant
101 competition for moisture, light, space and aeration which prompted the elongation of main
102 stem axis due to cellular elongation or expansion. The effect of closer spacing (42 plants m^{-2})
103 was supported by Singh and Sangama (2001).

104 Plant height (cm) was significantly affected by foliar spray of CalMax Gold at 75 and
105 100 DAT. (Table-1). By the comparison of means, we came to know that maximum plant
106 height (53.51 and 79.95 cm) was recorded with 5 foliar applications (S_3). Foliar spray of Zn
107 significantly increased plant height of Gerbera (Khosa *et al* 2011), increased height of Iris
108 plants (Khalifa *et al.*, 2011). Similar results were observed by Rahmati *et al.*, 2009 in pot
109 marigold. The result of Dadkhan *et al.*, 2012 expressed that, the use of foliar fertilizers
110 stimulate plant growth and better development of plants, leads to the increase in
111 morphological characters such as plant height.

112 **Plant spread**

113 It was recorded that pinching significantly increased plant spread at all the growing
114 stages. Significantly maximum planting spread of 13.12, 22.48 and 37.73 cm was recorded
115 with pinching plants (P_1). Pinching has significantly increased the plant spread in many crops
116 (Maharnor *et al.* 2011; Mohanty *et al.* 2012) as reported in marigold (Table 1).

Planting spread significantly improved with wider spacing. Maximum plant spread of 21.77 and 35.61 cm was observed in wider spacing of (D_1) at 75 and 100 DAT. This might be due to the availability of more space for growth of roots and shoots as well as utilization more nutrients by the plants. (Singh and Arora, 1988; Bhati and Chitkara, 1987 and Chanda and Roychoudhary, 1991). Similar trends in the reduction of plant spread with the closer spacing had also been reported by Dhemre *et al.* (1998) in China aster cv. 'White Powder Puff'.

Significantly maximum plant spread of plant (20.81 and 28.35 cm) in China aster were recorded with foliar application of CalMax gold at 75 and 100 DAT. An increased vegetative growth with foliar spray of CalMax gold might be due to the fact that, micronutrients and amino acids applied at optimum concentration is closely involved in metabolism of RNA and ribosomal content in plant cell which leads to stimulation of carbohydrates, proteins and DNA formation. It also helps in synthesis of tryptophan which acts as a growth promoting substance. Fe is also best in respect of growth of plant, which might have been due to the fact that, iron applied with proper concentration acts as an important catalyst in the enzymatic reaction of metabolism. This ultimately would have helped in larger biosynthesis of photoassimilates, thereby enhanced vegetative growth of plant. The results are in line with the findings of Karuppaiah (2014) and Saini *et al.* (2015) in chrysanthemum.

Leaf area

Leaf area had a direct influence of pinching treatments. Significantly higher leaf areas of 17.44.85, 3140.25 and 5883.25 cm² was recorded in pinching treatments (P_1) at 50, 75 and 100 DAT respectively. Similar results were reported by Dorajeerao and Mokashi, 2012 in chrysanthemum and Anuradha *et al.*, 2017 in African marigold (Table 2).

There was significant impact of spacing on leaf area of China aster. Significantly maximum leaf area (3003.00 and 5779.45 cm²) was recorded in wider spacing. This may be due to more number of secondary branches and more planting spread as obtained in wider spacing, which in turn contributed to less competition for space, nutrients, moisture and sunlight. Improved leaf area with wider spacing has been demonstrated in marigold (Yadav *et al.*, 2004) and China aster (Khobragade *et al.*, 2012) with less planting density per unit area.

Data regarding leaf area (cm²) showed that different frequency of CalMax gold effect on the leaf area (cm²) of China aster (Table 2). However, comparing the means of leaf area, it is clear from the mean table that significantly maximum (2951.75 and 5714.37 cm²) were recorded at 5 nutrient applications (S_3). Fe and Zn in CalMax gold is essential component of

several dehydrogenase, proteinase, peptidase and promotes growth hormones and closely associated with growth, all these factors contributed to cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the leaf area. Similar results were also found by Bashir *et al.* (2013) in gerbera. Zinc though stimulating metabolic activity with stimulating effect on cell wall loosening, increased cell elongation along with cell enlargement. All these caused effect on increased leaf area, thereby causing increased photosynthetic area. Thus enhanced in carbohydrate food material. Similar results were also obtained by Bashir *et al.* (2013) in gerbera.

Leaf area index

Pinching has significantly influence on LAI at all the intervals. Significantly maximum LAI (6.28, 11.27 and 21.15) was respectively recorded at 50, 75 and 100 DAT. Maximum LAI due to pinching may be attributed to the fact that pinching increases the planting spread, number of secondary branches and overall vegetative growth. Improved LAI with pinching has been reported in marigold (Anuradha *et al.*, 2017)

There was significant impact of spacing on LAI of China aster. Significantly maximum LAI (6.58, 12.03 and 23.63) was recorded in closer spacing. This may be due to more number of planting per unit area. Improved LAI with closest spacing has been demonstrated in marigold (Yadav *et al.*, 2004) and China aster (Khobragade *et al.* 2012) with less planting density per unit area (Table 2).

Data regarding LAI showed that different frequency of Calmax gold has significant effect on the LAI of China aster (Table 2). However, comparing the means of LAI, it is clear from the mean table that significantly maximum (10.59 and 20.53) were recorded at 5 nutrient application (S_3). The better plant growth observed in the present investigation may be attributed to the fact that an enhancement in cell multiplication and cell elongation in the presence of micronutrients (Fe and Zn). The active synthesis of tryptophan in the presence of Zn, the precursor of IAA stimulate the growth of plant tissue, while Fe is involved in the formation of chlorophyll, catalytic function, biological oxidation reduction and other metabolic processes in plants (Singh, 2004).

Chlorophyll content (SPAD)

Significant differences were observed among pinching treatments. Significantly higher chlorophyll content (34.32, 38.72 and 60.63) was recorded in pinched (P_1) plants than control (P_0) at 50, 75 and 100 DAT. The improved chlorophyll content may be attributed to the fact that with pinching there is more efficient portioning of photosynthates and improved

cellular growth and leaf expansion. Similar findings were observed by Sruthi praksh 2013MSc thesis while working on effect of pinching in marigold (Table 3).

Chlorophyll content was also positively influenced with planting density. Significantly maximum chlorophyll content (34.38, 37.47 and 59.85) was respectively recorded at 50, 75 and 100 DAT with the low planting density (D_1). This may be due to the fact that in wider spacing there is low competition for sunlight, nutrition and space thus results in more efficient accumulation and distribution of chlorophyll pigments.

Similarly the net chlorophyll content of China aster was significantly influenced with the frequency of nutrient sprays. Significantly maximum chlorophyll content (37.12 and 59.03) was recorded with 5 nutrient applications at 75 and 100 DAT. Among different micronutrients, iron is involved in the formation of chlorophyll, in catalytic function, in biological oxidation- reduction and other metabolic processes in plants *viz.*, oxidative photophosphorylation during cell respiration. Iron is also involved in carbohydrate metabolism and in protein synthesis. Moreover, micronutrients activate several enzymes (catalase, peroxidase, alcohol, dehydrogenase, carbonic dehydrogenase, tryptophan synthase etc.) and involved themselves in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged (Kumar and Arora, 2000). Also the Mg in Calmax gold is the main and direct constituent of chlorophyll molecule.

Number of primary branches/plant

The results (Table 3) indicated significant impact of pinching on number of primary branches per plant. The significantly maximum number of primary branches per plant (8.02, 12.59 and 16.64) was recorded at 50, 75 and 100 DAT when plants were subjected to pinching (P_1). Higher number of primary branches per plant may be due to pinching effect of apical buds which resulted in production of more branches and leaves owing to cessation of vertical growth. Decrease in plant height with increased number of leaves and branches due to pinching was reported in marigold (Sehrawat *et al.*, 2003 and Tomar *et al.*, 2004), in coriander (Iyyanngouda, 2003), in fenugreek (Sudarshan, 2004), in chrysanthemum (Singh and Baboo, 2003 and Grawal *et al.*, 2004) and in carnation (Pathania *et al.*, 2000 and Kumar and Singh, 2003).

Similarly significant influence of planting density had been observed on number of primary branches per plant. Significantly maximum number of primary branches (12.08 and 16.12) was recorded at 75 and 100 DAT with low planting density (D_1). Chanda and Roychoudhary (1991) reported that plant height, number of primary branches, number of flowers and flower yield per plant were higher at the wider spacing but yield per hectare was

highest at the closer spacing of 3m in African marigold .the results are also in conformity with that wider obtained by Khorbada *et al.*, 2012 while working on china aster.

Significant impacts of nutrient applications were obtained with the nutrient applications. Significantly maximum number of primary branches (12.20 and 16.24) was recorded at 75 and 100 DAT with 5 nutrient sprays (S₃). Increase in vegetative growth in respect to plant height, plant spread, number of leaves and number of branches per plant due to the micronutrients (Fe and Zn) can be attributed to improved root system of plants resulting in absorption of more water and nutrients and its utilization. The positive influence of zinc could be due to increase in shoot length and plant vigour, while iron is involved in carbohydrate metabolism and in protein synthesis. Mathew *et al.* (2004) reported that the foliar spray of 1500 ppm B- 9 + 0.5% Zn increased plant height and number of branches in African marigold cv. 'Pusa Basanti'.

Number of secondary branches/plant

The results indicated (Table 3) significant impact of pinching on number of secondary branches per plant. The significantly maximum number of primary branches per plant (14.00 and 23.19) was recorded at 75 and 100 DAT when plants were subjected to pinching (P₁). Higher number of primary branches per plant may be due to pinching effect of apical buds which resulted in production of more branches and leaves owing to cessation of vertical growth and elimination of apical dominance. Decrease in plant height and increase in number of branches due to pinching was reported in marigold (Sehrawat *et al.*, 2003 and Tomar *et al.*, 2004), in coriander (Iyyanngouda, 2003), in fenugreek (Sudarshan, 2004), in chrysanthemum (Singh and Baboo, 2003 and Grawal *et al.*, 2004) and in carnation (Pathania *et al.*, 2000 and Kumar and Singh, 2003).

Similarly significant influence of planting density had been observed on number of primary branches per plant. Significantly maximum number of secondary branches (13.40 and 22.45) was recorded at 75 and 100 DAT with low planting density (D₁). Chanda and Roychoudhary (1991) reported that number of secondary branches, were higher at the wider spacing in African marigold .the results are also in conformity with that wider obtained by Khorbada *et al.*, 2012 while working on china aster.

Significant impacts of nutrient applications were obtained with the nutrient applications. Significantly maximum number of secondary branches per plant (12.69 and 22.57) was recorded at 75 and 100 DAT with treatment S₃. Increase in vegetative growth in respect to plant height, plant spread, number of leaves and number of branches per plant due to the micronutrients (Fe and Zn) can be attributed to improved root system of plants

resulting in absorption of more water and nutrients and its utilization. The positive influence of zinc could be due to increase in shoot length and plant vigour, while iron is involved in carbohydrate metabolism and in protein synthesis. Mathew *et al.* (2004) reported that the foliar spray of 1500 ppm B- 9 + 0.5% Zn increased plant height and number of branches in African marigold cv. 'Pusa Basanti'.

Conclusion

Pinching deduced the plant height but was advantageous in improving plant spread, number of primary/secondary branches, leaf area and chlorophyll content. Higher plating density significantly increased the plant height, but the planting spread number of primary/secondary branches, chlorophyll content and leaf area was heist at wider planting density. Application of 5 and 4 nutrient sprays improved the overall growth of the plant like, plant height, leaf area, LAI, number of primary/secondary branches and chlorophyll content.

References

- Anuradha, R.W., Sateesh, R.P., Priyanka, T.K., Naveenakumar and Kulakarni, B.S. 2017. Effect of Growth Regulators and Pinching on Vegetative, Flowering and Flower Yield Parameters in African Marigold cv Culcatta Orange, *Int. J. Pure App. Biosci.* **5**(5): 989-994.
- Bashir, M.A., Waqas, A., Ahmad, K.S., Shafi, J., Shehzad, M.A., Sarwar, M.A., Ghani, I. and Iqbal, M. 2013. Efficacy of foliar application of micro nutrients on growth and flowering of *Gerbera jamesonii* L. *Universal J. Agric. Res.*, **1**(4): 145-149.
- Bhati R S and Chitkara S D. 1987. Effect of pinching and planting distance on the growth and yield of marigold (*Tagetes erecta*). *Res. Dev. Repr.* **4**: 159-164.
- Chanda S and Roychaudhary N. 1991. The effect of planting dates and spacing on growth, flowering and yield of African marigold (*Tagetes erecta* L.) cv. 'Siracole'. *The Horticulture Journal* **4**(2): 53-56.
- Dhemere J K, Shrisath N S, Nagaphade A S and Goudhali R V.1998. Effect of different planting densities and seasons on growth and flower quality of China aster. *Journal of Maharashtra Agricultural Universities* **23**(2): 118-120.
- Dorajeerao, A. V. D. and Mokashi, A. N. 2012. Branching pattern as influenced by pinching time in garland chrysanthemum (*Chrysanthemum coronarium* L.). *Indian Journal of Plant Sciences.* **1**(1):9-15.

284 Dzida, K., Z. Jarosz. 2006. Yielding and chemical composition of *Origanum majorana* L.
285 depending on different nitrogen-potassium fertilization. *Acta Agroph.* **7**(3): 561-566.

286 Golcz, B., Politycka, K. Seidler, Ł. 2006. The effect of nitrogen fertilization and stage of
287 plant development on the mass and quality of sweet basil leaves (*Ocimum basilicum*
288 L.). *Herba Pol.* **52** (1/2):22-30.

289 Grawal, H. S., Ramesh Kumar and Singh, H. 2004. Effect of nitrogen, planting time and
290 pinching on flower production in chrysanthemum cv. Flirt. *J. Ornamental Hort.*, **7**(2):
291 196-199.

292 Gyandev. B. 2006. Effect of pinching, plant nutrition and growth retardant sprays on seed
293 yield, quality and storage studies in China aster. M.Sc. thesis submitted to Department
294 of Horticulture, College of Agriculture, UAS, Dharwad

295 Iyyanagouda, S. 2003. Influence of spacing, nutrition, pinching and hormones on plant
296 growth, seed yield and quality of coriander (*Coriandrum sativum* L.). M.Sc. (Agri.)
297 Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India).

298 Karuppaiah, P. 2014. Effect of zinc and iron on growth, yield and quality of chrysanthemum
299 (*Dendratherum grandiflorum* Tzeuleu). *Asian J. Hort.*, **9**(1): 232-236.

300 Khalifa, R., Khan, M., Shaaban, S.H.A and Rawia, A. 2011. Effect of Foliar Application of
301 Zinc Sulfate and Boric Acid on Growth, Yield and Chemical Constituents of Iris Plants.
302 *Ozean J Appl Sci* **4**: 129-144.

303 Khobragade R., Bisen K., S and Thakur. R. S. 2012. Effect of planting distance and pinching
304 on growth, flowering and yield of China aster (*Callistephus chinensis*.) cv. Poornima.
305 *Indian Journal of Agricultural Sciences* **82**(4): 33-49

306 Khosa, S.S., Younis, A., Yameen, S., Riaj, A. 2011. Effect of foliar application of micro
307 nutrients on growth and flowering of gerbera (*Gerbera jamesonii*). *American Eurasian*
308 *Journal of Agri. Environ. Sci.*, **11**(5): 736-757.

309 Kumar, P. and Arora, J.S. 2000. Effect of micronutrients on gladiolus cv. 'White Prosperity'.
310 *Journal of Ornamental Horticulture.* **3**(2): 91-93.

311 Kumar, R. and Singh, K. (2003) Effect of growth regulator and shoot tip pinching on
312 carnation. *J. Ornamental Hort.*, **6**(2): 134-136.

313 Maharnor, S.I., Chopde, Neha, Thakre, Seema and Raut, P.D. 2011. Effect of nitrogen and
314 pinching on growth and yield of African marigold, *Asian Journal of Horticulture.* **6**(1):
315 43-45.

316 Mathew, R., Dashora, L.K. and Verma, P. 2004. Effect of growth retardants and
 317 micronutrients on growth and yield of African marigold (*Tagetes erecta* L.) cv. 'Pusa
 318 Basanti'. *Scientific Hort.*, **9**: 213-218.

319 Mohanty, C.R., Mohanty, A., and Parhi, A. 2012. Effects of planting dates and pinching on
 320 growth and flowering of African marigold cv. Sirakole. *Journal of ornamental*
 321 *horticulture*. 15 (1):102-107

322 Pathania, N. S., Sehgal, O. P. and Gupta, Y. C., 2000, Pinching for flower regulation in sim
 323 carnation. *J. Ornamental Hort.*, News Series, 3(2) 114-117.

324 Rahmati, M., Azizi, M., Hassanzadeh, M.K. and Neamati, H. 2009. The effects of different
 325 level of nitrogen and plant density on the agro morphological characters yield and
 326 essential oils content of improved chamomile (*Matricaria chamomilla* L.) cultivar
 327 "Bodegold". *J Hort Sci* **23**(1): 27-35

328 Saini, Tara Chand, Polara, N.D. and Bajad, A.A. 2015. Effect of micronutrients (Fe and Zn)
 329 on growth of chrysanthemum (*Chrysanthemum morifolium* Ramat.). *Asian J. Hort.*,
 330 **10**(2) : 216-221.

331 Sehrawat, S. K., Dahiya, D. S., Singh, S., Rana, G. S. and Singh, S. 2003. Effect of nitrogen
 332 and pinching on the growth, flowering and yield of marigold (*Tagetes erecta* L.) cv.
 333 African giant double orange. *Haryana Journal of Horticultural Science*, **32**(1-2): 59-61.

334 Sehrawat, S. K., Dahiya, D. S., Sukhbir Singh and Rana, G. S., 2003, Effect of nitrogen and
 335 pinching on growth, flowering and yield of marigold (*Tagetes erecta* L.) cv. African
 336 gaint double orange. *Haryana J. Hort. Sci.*, 32(1 & 2): 59 – 61.

337 Singh J and Arora J S. 1988. Effect of planting times and spacing on growth, flower and seed
 338 production of marigold cv. 'African Giant Double Orange'. *The Punjab Vegetable*
 339 *Grower* 23:41-44.

340 Singh K P and Sangama. 2001. Response of China aster to spacing. *Journal of Ornamental*
 341 *Horticulture* 4(1): 61–2.

342 Singh, M. K. and Baboo, R., 2003, Response of nitrogen, potassium and pinching levels on
 343 growth and flowering in chrysanthemum. *Journal of Ornamental Hort.*, 6(4): 390-393.

344 Singh, S. S. 2004. In: Soil fertility and nutrient management. Kalyani Publication, Ludhiana.

345 Sruthi Praksh. 2014. Impact of seasons and pinching on growth and flowering in african
 346 marigold (*Tagetes erecta* L.) Msc thesis submitted to Department of pomology and
 347 floriculture, College of agriculture. 2014

- Sudarshan, J. S. 2004. Influence of apical bud pinching, chemical spray and physiological maturity on seed yield and quality of fenugreek. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India).
- Tomar, B. S., Singh, B., Negi, H. C. S. and Singh, K. K. 2004. Effect of pinching on seed yield and quality traits in African marigold. *Journal of Ornamental Horticulture*, **7**(4): 124-126.
- Tomar, B. S., Singh, B., Negi, H. C. S. and Singh, K. K. 2004. Effect of pinching on seed yield and quality traits in African marigold. *J. Ornamental Hort.*, **7**(4) : 124-126.
- Yadav, R.M., Dubey, P. and Asati, B.S. 2004. Effect of spacing and nitrogen, levels on growth, flower yield of marigold (*Tagetes erecta* L.). *Orissa J. Hort.*, **32** (1) : 41-45
- Maheta P., Polara N.D., Rathod J., Barad A.V. and Bhosale N. 2016. Response of China Aster (*Callistephus chinensis* L. Nees) cv. Poornima to different levels of nitrogen and phosphorus in medium black soil. *HortFlora Res. Spectrum*, **5**(2): 120-123.
- Ozer, H. 2004. The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. *PLANT SOIL ENVIRON.*, **49**(9): 422-426

Table 1: Effect of pinching, planting density and nutrient sprays on plant height and plant spread of *Callistephus chinensis* cv. Powder Puff.

	Plant Height (cm)			Plant spread cm		
	50 DAT	75 DAT	100 DAT	50 DAT	75 DAT	100 DAT
Pinching						
P ₀ unpinched	40.16	54.57	81.17	11.50	16.16	25.90
P ₁ pinched	37.38	50.28	76.45	13.12	22.48	37.73
C.D ($p \leq 0.05$)	2.51	0.69	0.26	1.20	0.95	0.25
Planting density						
D ₁ (30 plants m ⁻²)	38.93	50.97	76.87	12.84	21.77	35.61
D ₂ (36 plants m ⁻²)	38.36	51.97	78.31	12.18	19.35	31.48
D ₃ (42 plants m ⁻²)	39.03	54.34	81.26	11.90	16.84	28.35
C.D ($p \leq 0.05$)	NS	0.85	0.32	NS	1.16	0.30
Sprays						
S ₁ (3 sprays)	37.88	51.76	77.86	12.59	18.03	31.22
S ₂ (4 sprays)	39.14	52.02	78.63	12.09	19.12	31.00

S ₃ (5 sprays)	39.29	53.51	79.95	12.24	20.81	33.22
C.D ($p \leq 0.05$)	NS	0.85	0.32	NS	1.16	0.30
Interaction						
P ₀ S ₁	38.00	53.59	79.99	11.52	15.30	26.09
P ₀ S ₂	41.14	54.14	80.80	11.40	16.02	25.01
P ₀ S ₃	41.35	55.99	82.72	11.57	17.16	26.59
P ₁ S ₁	37.49	49.92	75.97	13.60	20.76	36.35
P ₁ S ₂	37.34	49.89	76.54	12.75	22.22	37.00
P ₁ S ₃	37.31	51.04	76.85	13.00	24.46	39.84
C.D ($p \leq 0.05$)	NS	NS	0.45	NS	NS	0.43
P ₀ D ₁	38.45	52.33	78.55	12.48	19.20	29.71
P ₀ D ₂	41.32	53.76	78.55	10.91	16.17	25.26
P ₀ D ₃	40.72	57.64	78.55	11.11	13.11	22.72
P ₁ D ₁	39.42	49.62	75.19	13.20	24.34	41.52
P ₁ D ₂	35.39	50.18	75.19	13.45	22.53	37.70
P ₁ D ₃	37.33	51.05	75.19	12.70	20.57	33.97
C.D ($p \leq 0.05$)	NS	1.20	0.45	NS	NS	0.43
P ₀ S ₁ D ₁	38.10	51.46	77.22	12.51	18.97	29.35
P ₀ S ₁ D ₂	39.50	53.02	79.70	11.01	14.99	23.72
P ₀ S ₁ D ₃	36.41	56.28	83.07	11.04	11.95	25.19
P ₀ S ₂ D ₁	40.16	52.35	78.91	12.39	19.24	29.49
P ₀ S ₂ D ₂	43.06	53.31	79.90	10.69	15.74	24.86
P ₀ S ₂ D ₃	40.19	56.77	83.59	11.13	13.09	20.68
P ₀ S ₃ D ₁	37.09	53.17	79.52	12.53	19.40	30.29
P ₀ S ₃ D ₂	41.40	54.95	81.47	11.03	17.78	27.19
P ₀ S ₃ D ₃	45.55	59.86	87.18	11.16	14.30	22.29
P ₁ S ₁ D ₁	40.62	49.24	74.55	13.89	21.58	39.20
P ₁ S ₁ D ₂	34.86	50.26	76.12	13.84	21.50	37.22
P ₁ S ₁ D ₃	37.00	50.27	77.23	13.08	19.20	32.64
P ₁ S ₂ D ₁	39.89	49.58	75.14	13.56	23.72	39.97
P ₁ S ₂ D ₂	35.22	49.19	76.28	13.15	22.72	37.63
P ₁ S ₂ D ₃	36.90	50.91	78.18	11.54	20.22	33.40
P ₁ S ₃ D ₁	37.73	50.03	75.87	12.16	27.71	45.37
P ₁ S ₃ D ₂	36.10	51.09	76.37	13.36	23.39	38.27

P ₁ S ₃ D ₃	38.10	51.99	78.32	13.48	22.28	35.88
C.D ($p \leq 0.05$)	NS	NS	0.78	NS	NS	0.74

Table 2: Effect of pinching, planting density and nutrient sprays on leaf area and leaf area index (LAI) of *Callistephus chinensis* cv. Powder Puff.

Leaf area cm ²				LAI		
	50 DAT	75 DAT	100 DAT	50 DAT	75 DAT	100 DAT
Pinching						
P ₀ unpinched	1413.20	2711.60	5501.03	5.07	9.74	19.77
P ₁ pinched	1744.85	3140.25	5883.25	6.28	11.27	21.15
C.D ($p \leq 0.05$)	57.33	24.925	6.585	0.186	0.076	0.019
Planting density						
D ₁ (30 plants m ⁻²)	1610.15	3003.00	5779.45	4.83	9.01	17.34
D ₂ (36 plants m ⁻²)	1560.08	2910.81	5671.91	5.62	10.48	20.42
D ₃ (42 plants m ⁻²)	1566.84	2863.96	5625.06	6.58	12.03	23.63
C.D ($p \leq 0.05$)	NS	30.527	8.065	0.228	0.093	0.023
Sprays						
S ₁ (3 sprays)	1575.18	2911.79	5685.91	5.66	10.46	20.44
S ₂ (4 sprays)	1615.19	2914.23	5676.15	5.79	10.46	20.41
S ₃ (5 sprays)	1546.70	2951.75	5714.37	5.58	10.59	20.53
C.D ($p \leq 0.05$)	NS	30.527	8.065	NS	0.093	0.023
Interaction						
P ₀ S ₁	1408.11	2706.12	5506.84	5.06	9.73	19.79
P ₀ S ₂	1409.63	2704.30	5471.15	5.06	9.72	19.67
P ₀ S ₃	1421.87	2724.37	5525.09	5.10	9.79	19.84
P ₁ S ₁	1742.25	3117.46	5864.97	6.25	11.20	21.10
P ₁ S ₂	1820.75	3124.16	5881.15	6.53	11.21	21.15
P ₁ S ₃	1671.53	3179.13	5903.64	6.06	11.40	21.22
C.D ($p \leq 0.05$)	NS	NS	11.406	NS	NS	0.032
P ₀ D ₁	1458.42	2759.77	5605.47	4.38	8.28	16.82
P ₀ D ₂	1412.76	2708.60	5470.98	5.09	9.75	19.70
P ₀ D ₃	1368.41	2666.43	5426.63	5.75	11.2	22.79

P ₁ D ₁	1761.87	3246.24	5953.42	5.29	9.74	17.86
P ₁ D ₂	1707.39	3113.02	5872.84	6.15	11.21	21.14
P ₁ D ₃	1765.27	3061.49	5823.49	6.15	12.86	24.46
C.D ($p \leq 0.05$)	NS	43.171	11.406	NS	NS	0.032
P ₀ S ₁ D ₁	1437.51	2739.41	5617.29	4.31	8.22	16.85
P ₀ S ₁ D ₂	1414.99	2715.23	5473.21	5.09	9.77	19.70
P ₀ S ₁ D ₃	1371.82	2663.72	5430.03	5.76	11.19	22.81
P ₀ S ₂ D ₁	1458.97	2759.20	5527.09	4.38	8.28	16.58
P ₀ S ₂ D ₂	1408.30	2691.87	5466.52	5.07	9.69	19.68
P ₀ S ₂ D ₃	1361.61	2661.84	5419.83	5.72	11.18	22.76
P ₀ S ₃ D ₁	1478.79	2780.69	5672.03	4.44	8.34	17.02
P ₀ S ₃ D ₂	1414.99	2718.71	5473.21	5.09	9.79	19.70
P ₀ S ₃ D ₃	1371.82	2673.72	5430.03	5.76	11.23	22.81
P ₁ S ₁ D ₁	1859.21	3200.48	5917.43	5.58	9.60	17.75
P ₁ S ₁ D ₂	1594.27	3089.05	5852.48	5.74	11.12	21.07
P ₁ S ₁ D ₃	1773.28	3062.86	5824.98	7.45	12.86	24.46
P ₁ S ₂ D ₁	1895.19	3226.58	5953.4	5.69	9.68	17.86
P ₁ S ₂ D ₂	1811.29	3093.66	5869.54	6.52	11.14	21.13
P ₁ S ₂ D ₃	1755.78	3052.24	5820.51	7.37	12.82	24.45
P ₁ S ₃ D ₁	1531.21	3311.66	5989.43	4.59	9.93	17.97
P ₁ S ₃ D ₂	1716.62	3156.36	5896.5	6.18	11.36	21.23
P ₁ S ₃ D ₃	1766.77	3069.36	5824.98	7.42	12.89	24.46
C.D ($p \leq 0.05$)	NS	NS	19.756	0.557	NS	0.056

374

375

376 **Table 3: Effect of pinching, planting density and nutrient sprays on chlorophyll content,**
377 **No. of primary/secondary branches plant⁻¹ of *Callistephus chinensis* cv.**
378 **Powder Puff.**

Chlorophyll content (SPAD)				No. of primary branches			No. of secondary branches	
	50 DAT	75 DAT	100 DAT	50 DAT	75 DAT	100 DAT	50 DAT	75 DAT
Pinching								
P ₀ unpinched	31.67	32.86	54.55	7.43	11.40	15.44	9.94	21.44
P ₁ pinched	34.32	38.72	60.63	8.02	12.59	16.64	14.0	23.19
C.D ($p \leq 0.05$)	1.674	0.975	1.537	0.471	0.052	0.052	0.584	0.052

Planting density								
D ₁ (30 plants m ⁻²)	34.38	37.47	59.85	7.90	12.08	16.12	13.40	22.45
D ₂ (36 plants m ⁻²)	33.06	36.07	57.78	7.76	11.95	16.00	11.72	22.24
D ₃ (42 plants m ⁻²)	31.55	33.82	55.14	7.51	11.96	16.00	10.77	22.25
C.D ($p \leq 0.05$)	2.05	1.19	1.88	NS	0.06	0.06	0.72	0.06
Sprays								
S ₁ (3 sprays)	32.72	34.9	55.76	7.60	11.75	15.80	11.34	22.04
S ₂ (4 sprays)	32.92	35.35	57.99	7.72	12.04	16.08	11.87	22.33
S ₃ (5 sprays)	33.35	37.12	59.03	7.84	12.20	16.24	12.69	22.57
C.D ($p \leq 0.05$)	NS	1.19	1.88	NS	0.06	0.06	0.72	0.064
Interaction								
P ₀ S ₁	31.35	31.93	52.45	7.28	11.24	15.28	9.38	21.28
P ₀ S ₂	31.57	32.66	55.07	7.31	11.45	15.49	9.84	21.49
P ₀ S ₃	32.08	33.97	56.14	7.70	11.52	15.56	10.59	21.56
P ₁ S ₁	34.09	37.86	59.06	7.92	12.27	16.31	13.30	22.81
P ₁ S ₂	34.27	38.03	60.91	8.13	12.64	16.68	13.90	23.18
P ₁ S ₃	34.61	40.26	61.93	7.99	12.87	16.91	14.79	23.57
C.D ($p \leq 0.05$)	NS	NS	11.41	NS	0.09	0.09	NS	0.09
P ₀ D ₁	33.23	33.58	56.45	7.54	11.10	14.95	11.37	20.95
P ₀ D ₂	31.28	33.38	54.98	7.50	11.59	15.52	9.74	21.52
P ₀ D ₃	30.49	31.61	52.22	7.24	11.87	15.86	8.70	21.86
P ₁ D ₁	35.53	41.36	63.25	8.25	13.82	17.29	15.44	23.96
P ₁ D ₂	34.83	38.75	60.58	8.01	12.50	16.48	13.70	22.97
P ₁ D ₃	32.61	36.03	58.06	7.79	12.28	16.14	12.85	22.64
C.D ($p \leq 0.05$)	NS	NS	NS	NS	0.09	0.03	NS	0.09
P ₀ S ₁ D ₁	32.46	33.08	55.18	7.59	10.59	14.63	10.71	20.63
P ₀ S ₁ D ₂	31.07	32.19	52.88	7.09	11.37	15.41	9.04	21.41
P ₀ S ₁ D ₃	30.54	30.52	49.30	7.15	11.77	15.81	8.38	21.81
P ₀ S ₂ D ₁	32.62	33.52	56.46	7.52	11.04	15.08	11.35	21.08
P ₀ S ₂ D ₂	31.31	32.98	55.82	7.18	11.48	15.52	9.44	21.52
P ₀ S ₂ D ₃	30.77	31.49	52.92	7.23	11.82	15.86	8.75	21.86
P ₀ S ₃ D ₁	34.61	34.14	57.73	7.52	11.10	15.14	12.04	21.14
P ₀ S ₃ D ₂	31.47	34.96	56.24	8.23	11.59	15.63	10.74	21.63
P ₀ S ₃ D ₃	30.16	32.82	54.43	7.33	11.87	15.91	8.98	21.91
P ₁ S ₁ D ₁	35.53	39.57	61.67	8.18	12.57	16.61	14.56	23.11
P ₁ S ₁ D ₂	34.21	39.20	58.34	7.91	12.30	16.37	13.29	22.84

P ₁ S ₁ D ₃	32.53	34.82	57.15	7.67	11.93	15.97	12.04	22.47
P ₁ S ₂ D ₁	36.80	40.17	63.85	8.56	13.37	17.41	15.10	23.91
P ₁ S ₂ D ₂	33.83	38.08	60.59	8.05	12.48	16.52	13.71	23.02
P ₁ S ₂ D ₃	32.20	35.83	58.30	7.79	12.08	16.12	12.90	22.62
P ₁ S ₃ D ₁	34.28	44.35	64.24	8.01	13.82	17.86	16.65	24.85
P ₁ S ₃ D ₂	36.47	38.98	62.82	8.07	12.50	16.54	14.11	23.04
P ₁ S ₃ D ₃	33.09	37.45	58.74	7.90	12.28	16.32	13.60	22.82
C.D ($p \leq 0.05$)	NS	NS	NS	NS	0.16	0.16	NS	0.16