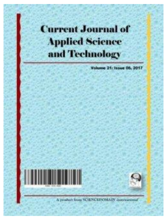

Current Journal of Applied Science and Technology

26(4): 1-11, 2018; Article no.CJAST.40510
ISSN: 2457-1024
*(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843,
NLM ID: 101664541)*

Phytomorphology of *Callistephus chinensis* as Influenced by Differential Planting Geometry, Pinching and Compound Nutrient Sprays

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Authors' contributions

This work was carried out under the supervision of all authors. Author MAW designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FUK and ITN managed the analyses of the study. Authors FAK, SHK, TA and Neelofar helped in literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/40510
Editor(s):
(1) Hamid El Bilali, Centre for Development Research, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.
Reviewers:
(1) Rocky Thokchom, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, India.
(2) Salman Mushtaq, Institute of Horticultural sciences, University of Agriculture Faisalabad, Pakistan.
Complete Peer review History: http://www.sciencedomain.org/review-history/23856

Original Research Article

Received 3rd January 2018
Accepted 26th March 2018
Published 29th March 2018

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

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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.

1. 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 [1]. 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 [2]. 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 [3] in different annuals have reported improved vegetative growth through micronutrient sprays thus resulting in enhanced returns per unit area. Numerous studies [4,5,6] 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 under taken with objective. To study the influence of pinching, planting density and nutrient sprays on vegetative attributes of China aster cv. Powder puff.

2. MATERIALS 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 was conducted during the years 2016 and 2017 at and the data presented is pooled over the years. 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					

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

2.1 Observations Recorded

2.1.1 Plant height (cm)

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

2.1.2 Plant spread (cm)

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

2.1.3 Leaf area (cm^2)

The leaf area $plant^{-1}$ was taken at 50, 75 and 100 DAT with the help of leaf area meter in cm^2.

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

2.1.4 Leaf area index (LAI)

Leaf area was calculated with the use of following equation

$$LAI = Leaf\ Area \div Ground\ Area$$

2.1.5 Chlorophyll content

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

2.1.6 Number of primary branches per plant

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

2.1.7 Number of secondary branches/plant

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

3. RESULTS AND DISCUSSION

3.1 Plant Height

Between pinching and no pinching treatments (Table 1), non pinched plants (P_0) recorded significantly more plant height at 50, 75 DAT and at 100 DAT (40.16, 54.57 and 81.17 cm, respectively) compared to pinched plants. It might be due to the reason of apical dominance in case of unpinched plants and no pinched plant grew upto the original height without reduction as supported with the findings of Sehrawat [7] and Tomar [8] in African marigold, Gyandev [9] and Khobragade [10] in China aster.

It was observed that the magnitude of plant height was maximum at the closer spacing of (D_3) and decreased gradually as the spacing increased in all the observation recorded at 75 and 100 days after transplanting. The maximum plant height was 81.26 cm in a spacing of D_3 (100 DAT). The increased plant height in closer spacing might be due to intra plant competition for moisture, light, space and aeration which prompted the elongation of main stem axis due to cellular elongation or expansion. The effect of closer spacing (42 plants m^{-2}) was supported by Singh and Sangama [11].

Plant height (cm) was significantly affected by foliar spray of CalMax Gold at 75 and 100 DAT. (Table 1). By the comparison of means, we came to know that maximum plant height (53.51 and 79.95 cm) was recorded with 5 foliar applications (S_3). Foliar spray of Zn significantly increased plant height of Gerbera [12], increased height of Iris plants [13]. Similar results were observed by Rahmati [14] in pot marigold. The use of foliar fertilizers stimulates plant growth and better development of plants, leads to the increase in morphological characters such as plant height.

3.2 Plant Spread

It was recorded that pinching significantly increased plant spread at all the growing stages. Significantly maximum planting spread of 13.12, 22.48 and 37.73 cm was recorded with pinching plants (P_1). Pinching has significantly increased the plant spread in many crops [15,16] as reported in marigold (Table 1).

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_0S_1	38.00	53.59	79.99	11.52	15.30	26.09
P_0S_2	41.14	54.14	80.80	11.40	16.02	25.01
P_0S_3	41.35	55.99	82.72	11.57	17.16	26.59
P_1S_1	37.49	49.92	75.97	13.60	20.76	36.35
P_1S_2	37.34	49.89	76.54	12.75	22.22	37.00
P_1S_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_0D_1	38.45	52.33	78.55	12.48	19.20	29.71
P_0D_2	41.32	53.76	78.55	10.91	16.17	25.26
P_0D_3	40.72	57.64	78.55	11.11	13.11	22.72
P_1D_1	39.42	49.62	75.19	13.20	24.34	41.52
P_1D_2	35.39	50.18	75.19	13.45	22.53	37.70
P_1D_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**
$P_0S_1D_1$	38.10	51.46	77.22	12.51	18.97	29.35
$P_0S_1D_2$	39.50	53.02	79.70	11.01	14.99	23.72
$P_0S_1D_3$	36.41	56.28	83.07	11.04	11.95	25.19
$P_0S_2D_1$	40.16	52.35	78.91	12.39	19.24	29.49
$P_0S_2D_2$	43.06	53.31	79.90	10.69	15.74	24.86
$P_0S_2D_3$	40.19	56.77	83.59	11.13	13.09	20.68
$P_0S_3D_1$	37.09	53.17	79.52	12.53	19.40	30.29
$P_0S_3D_2$	41.40	54.95	81.47	11.03	17.78	27.19
$P_0S_3D_3$	45.55	59.86	87.18	11.16	14.30	22.29
$P_1S_1D_1$	40.62	49.24	74.55	13.89	21.58	39.20
$P_1S_1D_2$	34.86	50.26	76.12	13.84	21.50	37.22
$P_1S_1D_3$	37.00	50.27	77.23	13.08	19.20	32.64
$P_1S_2D_1$	39.89	49.58	75.14	13.56	23.72	39.97
$P_1S_2D_2$	35.22	49.19	76.28	13.15	22.72	37.63
$P_1S_2D_3$	36.90	50.91	78.18	11.54	20.22	33.40
$P_1S_3D_1$	37.73	50.03	75.87	12.16	27.71	45.37
$P_1S_3D_2$	36.10	51.09	76.37	13.36	23.39	38.27
$P_1S_3D_3$	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**

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 [17,18] and [19]. Similar trends in the reduction of plant spread with the closer spacing had also been reported by Dhemere [20] 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 [21] and Saini [22] in chrysanthemum.

3.3 Leaf Area

Leaf area had a direct influence of pinching treatments. Significantly higher leaf areas of 1744.85, 3140.25 and 5883.25 cm^2 was recorded in pinching treatments (P_1) at 50, 75 and 100 DAT respectively. Similar results were reported in chrysanthemum [23] and Anuradha [24] 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 cm^2) 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 [25] and China aster [10] with less planting density per unit area.

Data regarding leaf area (cm^2) showed that different frequency of CalMax gold effect on the leaf area (cm^2) 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 cm^2) 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 [26] in gerbera. Zinc though stimulating metabolic activity with stimulating effect on cell wall loosing, 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 [26] in gerbera.

3.4 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 [24].

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 [25] and China aster [10] 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 [27].

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_0S_1	1408.11	2706.12	5506.84	5.06	9.73	19.79
P_0S_2	1409.63	2704.30	5471.15	5.06	9.72	19.67
P_0S_3	1421.87	2724.37	5525.09	5.10	9.79	19.84
P_1S_1	1742.25	3117.46	5864.97	6.25	11.20	21.10
P_1S_2	1820.75	3124.16	5881.15	6.53	11.21	21.15
P_1S_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_0D_1	1458.42	2759.77	5605.47	4.38	8.28	16.82
P_0D_2	1412.76	2708.60	5470.98	5.09	9.75	19.70
P_0D_3	1368.41	2666.43	5426.63	5.75	11.2	22.79
P_1D_1	1761.87	3246.24	5953.42	5.29	9.74	17.86
P_1D_2	1707.39	3113.02	5872.84	6.15	11.21	21.14
P_1D_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**
$P_0S_1D_1$	1437.51	2739.41	5617.29	4.31	8.22	16.85
$P_0S_1D_2$	1414.99	2715.23	5473.21	5.09	9.77	19.70
$P_0S_1D_3$	1371.82	2663.72	5430.03	5.76	11.19	22.81
$P_0S_2D_1$	1458.97	2759.20	5527.09	4.38	8.28	16.58
$P_0S_2D_2$	1408.30	2691.87	5466.52	5.07	9.69	19.68
$P_0S_2D_3$	1361.61	2661.84	5419.83	5.72	11.18	22.76
$P_0S_3D_1$	1478.79	2780.69	5672.03	4.44	8.34	17.02
$P_0S_3D_2$	1414.99	2718.71	5473.21	5.09	9.79	19.70
$P_0S_3D_3$	1371.82	2673.72	5430.03	5.76	11.23	22.81
$P_1S_1D_1$	1859.21	3200.48	5917.43	5.58	9.60	17.75
$P_1S_1D_2$	1594.27	3089.05	5852.48	5.74	11.12	21.07
$P_1S_1D_3$	1773.28	3062.86	5824.98	7.45	12.86	24.46
$P_1S_2D_1$	1895.19	3226.58	5953.4	5.69	9.68	17.86
$P_1S_2D_2$	1811.29	3093.66	5869.54	6.52	11.14	21.13
$P_1S_2D_3$	1755.78	3052.24	5820.51	7.37	12.82	24.45
$P_1S_3D_1$	1531.21	3311.66	5989.43	4.59	9.93	17.97
$P_1S_3D_2$	1716.62	3156.36	5896.5	6.18	11.36	21.23
$P_1S_3D_3$	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**

3.5 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 finding were observed by Sruthi Praksh [28] 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 dehydrogenize, tryptophane synthates etc.) and involved themselves in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged [29]. Also the Mg in CalMax gold is the main and direct constituent of chlorophyll molecule.

3.6 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 an 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 [7] and [8], in coriander [30], in fenugreek [31], in chrysanthemum [32,33] and in carnation [34,35].

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 [19] 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 3em in African marigold .the results are also in conformity with that wider obtained by Khobragade [10] 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 (S_3). 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 [36] 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'.

3.7 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 (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 and elimination of apical dominance. Decrease in plant height and increase in number of branches due to pinching was reported in marigold [7,8], in coriander [30] in fenugreek [31] in chrysanthemum [32], 2003 and [33] and in carnation [34] and [35].

Table 3. Effect of pinching, planting density and nutrient sprays on chlorophyll content, No. of primary/secondary branches plant^{-1} of *Callistephus chinensis* cv. 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**	**75 DAT**	**100 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_0S_1	31.35	31.93	52.45	7.28	11.24	15.28	9.38	21.28
P_0S_2	31.57	32.66	55.07	7.31	11.45	15.49	9.84	21.49
P_0S_3	32.08	33.97	56.14	7.70	11.52	15.56	10.59	21.56
P_1S_1	34.09	37.86	59.06	7.92	12.27	16.31	13.30	22.81
P_1S_2	34.27	38.03	60.91	8.13	12.64	16.68	13.90	23.18
P_1S_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_0D_1	33.23	33.58	56.45	7.54	11.10	14.95	11.37	20.95
P_0D_2	31.28	33.38	54.98	7.50	11.59	15.52	9.74	21.52
P_0D_3	30.49	31.61	52.22	7.24	11.87	15.86	8.70	21.86
P_1D_1	35.53	41.36	63.25	8.25	13.82	17.29	15.44	23.96
P_1D_2	34.83	38.75	60.58	8.01	12.50	16.48	13.70	22.97
P_1D_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**
$P_0S_1D_1$	32.46	33.08	55.18	7.59	10.59	14.63	10.71	20.63
$P_0S_1D_2$	31.07	32.19	52.88	7.09	11.37	15.41	9.04	21.41
$P_0S_1D_3$	30.54	30.52	49.30	7.15	11.77	15.81	8.38	21.81
$P_0S_2D_1$	32.62	33.52	56.46	7.52	11.04	15.08	11.35	21.08
$P_0S_2D_2$	31.31	32.98	55.82	7.18	11.48	15.52	9.44	21.52
$P_0S_2D_3$	30.77	31.49	52.92	7.23	11.82	15.86	8.75	21.86
$P_0S_3D_1$	34.61	34.14	57.73	7.52	11.10	15.14	12.04	21.14
$P_0S_3D_2$	31.47	34.96	56.24	8.23	11.59	15.63	10.74	21.63
$P_0S_3D_3$	30.16	32.82	54.43	7.33	11.87	15.91	8.98	21.91
$P_1S_1D_1$	35.53	39.57	61.67	8.18	12.57	16.61	14.56	23.11
$P_1S_1D_2$	34.21	39.20	58.34	7.91	12.30	16.37	13.29	22.84
$P_1S_1D_3$	32.53	34.82	57.15	7.67	11.93	15.97	12.04	22.47
$P_1S_2D_1$	36.80	40.17	63.85	8.56	13.37	17.41	15.10	23.91
$P_1S_2D_2$	33.83	38.08	60.59	8.05	12.48	16.52	13.71	23.02
$P_1S_2D_3$	32.20	35.83	58.30	7.79	12.08	16.12	12.90	22.62
$P_1S_3D_1$	34.28	44.35	64.24	8.01	13.82	17.86	16.65	24.85
$P_1S_3D_2$	36.47	38.98	62.82	8.07	12.50	16.54	14.11	23.04
$P_1S_3D_3$	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**

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 (D_1). Chanda and Roychoudhary [19] 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 Khobragade [10] 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 S_3. 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 [36] reported that the foliar spray of 1500 ppm B- 9 + 0.5% Zn increased plant height and number of branches in African marigold.

4. 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.

ACKNOWLEDGEMENTS

I'd like to express my sincere gratitude to UGC (University Grants Commission), Govt. of India for providing the financial support during the course of my doctoral programme.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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