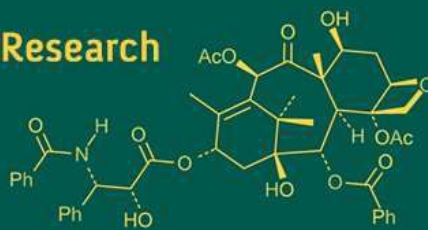
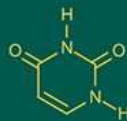


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Studies on the effect of micronutrients (Zn, Fe and B) on growth, flowering and yield of China aster (*Callistephus chinensis* L.) under agroclimatic condition of Chhattisgarh plains

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Abstract

The present investigation studies on the effect of micronutrients (Zn, Fe and B) on growth, flowering and yield of china aster (*Callistephus chinensis* L.) under agroclimatic condition of Chhattisgarh plains was undertaken at Department of Floriculture and Landscape Architecture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during the year 2022 – 2023. An experiment was conducted to evaluate the effect of micronutrients on growth, flowering and yield parameter of china aster. The experimental data consisted of 13 treatments and 3 replications under randomized block design (RBD). The results indicate that the growth parameter viz., plant height (cm), number of leaves, number of primary and secondary branches per plant, plant spread N-S and E-W (cm), chlorophyll content, plant analysis. Flower parameter viz., days taken to first flower bud appearance, days to flower open, flower diameter (cm), number of flower bud per plant, number of flower per plant and yield parameter viz., average weight of flower, flower yield per plant and flower yield (t/ha). The results revealed that growth, flowering and yield parameter maximum were recorded was at the application of T₁₂ - (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) followed by T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%). While the minimum were observed under T₀ (without application control).

Keywords: Micronutrient, China aster and chlorophyll content

Introduction

China aster [*Callistephus chinensis* (L.) Nees] belongs to one of the largest families of flowering plants, 'Asteraceae'. It's diploid (2n) chromosome number is 18. The genus *Callistephus* has only a single species *Callistephus chinensis*. Linnaeus named it *Aster chinensis* at first, but it was renamed to *Callistephus chinensis* by Nees. The single species chinensis belong to the genus *Callistephus*. The name *Callistephus* is derivative from two Greek words: Kalistos, which means most attractive and Stephus, which means crown. It symbolizes purity, love, peace, beauty and passion (Naikwad *et al.*, 2018) [22].

It is native to China has spread to Europe and other tropical countries during 1731 A.D. (Desai, 1967) [6]. It is also an important flower crop of Siberia, USSR, Japan, North America, Switzerland and Europe. It is grown successfully in open conditions for year round production in kharif, rabi and summer to have continuous supply of flowers to the market. It is one of the most important annual flower crops grown in most parts of the world. Aster is a winter seasonal annual flower crop that is half-hardy; free blooming and easy to grow. The plant are erect with leaves are arranged alternately on branches and bear solitary type of flower (Bohra *et al.*, 2019) [4].

The plant was around 60 cm tall and single blooming type and branching type. There are two types of florets in an aster bloom: ray florets and disc florets. The bloom type depends mainly upon the relative number of the two kinds of florets and their shapes. The most suitable feature for the classification of China aster is the form of ray florets. Since its arrival to Europe, the plants form, size and colour of bloom have changed significantly (Chopde, 2016) [5].

The China aster has become one of the most popular garden flowers. Among the colours present in all of the many variations are pure white, purple, dark blue, numerous shades of pink, pastel blue, and red. Aster does not have a pure golden color. Flower with more petals are ideal for use as loose flowers in garlands, buttonholes and veni for hair ornamentation. Aster flower plants are a popular bedding plant in landscape gardening and use as a pot plant, as well as in a mixed herbaceous border and are ideal for window boxes and edging. The China aster is now widely regarded as one of the most beautiful garden flowers (Kirar *et al.*, 2009 and Kumar *et al.*, 2018) ^[15, 17].

Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients; boron (B), iron (Fe), zinc (Zn), copper (Cu), chloride (Cl), manganese (Mn), molybdenum (Mo) and nickel (Ni). These elements are active that makes them essential as catalytically active cofactors of enzymes, others have enzyme-activating functions and yet others fulfill a structural role in stabilizing proteins. Improvement in growth characters due to micronutrient application might basically be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation as opined by (Hatwar *et al.*, 2003) ^[10].

Zinc plays an important role in the production of biomass. It may be required for chlorophyll production, pollen function, fertilization. It was also reported by many researchers that zinc had a significant effect on corm and cormel production

in *Gladiolus* (Halder *et al.*, 2007) ^[9]. Recently, foliar fertilizers are extensively used in vegetable, fruit crops and ornamental plants that contain various macro and micronutrients, which are necessary for the proper growth and yield.

Iron is redox-active metal, it is involved in photosynthesis, mitochondrial respiration, nitrogen assimilation, hormone biosynthesis (ethylene, gibberellic acid, and jasmonic acid), scavenging of reactive oxygen species, osmoprotection and pathogen defense. Singh and Bhattacharjee (1997) ^[27] reported in rose that the foliar spray of 2 per cent ferrous sulphate was best for promoting early flowering and increased flower diameter and longevity.

Boron is essential for plant growth, new cell division in meristematic tissue, translocation of sugar, starch, nitrogen, phosphorus, certain hormones, synthesis of amino acids and protein, regulations of carbohydrate metabolism, development of phloem etc. In the absence of adequate supply, middle lamella of new cell develops poorly and phloem tubes break down (Edmond *et al.*, 1997) ^[7].

Materials and Methods

The research work was conducted at Horticultural Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2022-23 in Rabi season. The experiment was conducted on china aster with 13 treatment and three replication in Randomized block design and were spaced at 30 cm x 30 cm.

Treatment combinations

Notations to be used	Treatments
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)
T ₂	RDF+ Iron @ 0.2%
T ₃	RDF + Iron @ 0.4%
T ₄	RDF + Iron @ 0.6%
T ₅	RDF + Zinc @ 0.2%
T ₆	RDF + Zinc @ 0.4%
T ₇	RDF + Zinc @ 0.6%
T ₈	RDF + Boron @ 0.2%
T ₉	RDF + Boron @ 0.4%
T ₁₀	RDF + Boron @ 0.6%
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%

Result

It is evident from the Table 1 that the effect of different micronutrient on plant height at 90 days after transplanting was varied from 61.08 to 65.85 cm. The highest plant height (65.85 cm) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was noted at par with treatment T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). Where as it was showed significantly differ with rest of other treatments. The minimum plant height (61.08 cm) was observed with treatment T₁ control.

The ability of zinc to synthesis tryptophan, a precursor of indole acetic acid (auxin), may be the cause of the improvement in the vegetative growth characteristics of China asters following the application of zinc sulphate. In addition, zinc activates a number of enzymes, including carbonic anhydrase, pyridine nucleotide dehydrogenase, and alcohol dehydrogenase. Additionally, ferrous ammonium sulphate is a crucial enzyme catalyst, and optimal enzyme

synthesis increases metabolic activity that may be enhance the plant height. Saini *et al.* (2015) ^[26] and Chopde (2016) ^[5] all came to similar conclusions in chrysanthemum and Kumar *et al.* (2003) ^[16] in carnation.

As far as at 90 days after transplanting the number of leaves per plant was varied from 168.45 to 181.23. The maximum number of leaves per plant (181.23) was recorded in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) and it was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However, it was showed significantly differ with remaining all of other treatments. The minimum number of leaves per plant was (168.45) observed with treatment T₁ control.

The greater number of leaves per plant might be due application of micronutrient may be a result of zinc's contribution to increased tryptophan synthesis, which is necessary for the metabolism of nitrogen and a growth-stimulating hormone called auxin. Similarly iron serves as a

crucial catalyst in metabolic enzymatic operations, it would have aided in increased photoassimilates' production, that may be promoting plant development. Similar results were also reported by Muthumanickam *et al.* (1999) ^[20] and Jadhav (2004) ^[11] in gerbera, Juhari *et al.* (2005) ^[12], Balakrishnan (2005) ^[1] in Gladiolus and Pal. *et al.* (2016) ^[23] in Gerbera.

The number of primary branches per plant at 90 days after transplanting was varied from 14.05 to 18.73. The highest number of primary branches per plant (18.73) was recorded with in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) and it was showed at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The lowest number of primary branches per plant was (14.05) observed with treatment T₁ control.

The number of secondary branches per plant at 90 days after transplanting was varied from 24.53 to 32.13. The highest number of secondary branches per plant (38.13) was

obtained in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The lowest number of secondary branches per plant was (24.53) observed with treatment T₁ control.

Application of micronutrients like ZnSO₄, which is a crucial component of several dehydrogenases, proteinases, and peptidases and promotes growth hormones and is closely linked to plant growth and development may be the cause of the increase in the number of primary and secondary branches per plant. These factors all contributed to cell multiplication, cell division, and cell differentiation resulting in increased photosynthesis and translocation of food material, which may be the cause of the increase in the number of secondary branches. Pal *et al.*, (2016) ^[26] verified the above result in Gerbera and similar result was also obtained by Kakade *et al.* (2009) ^[14] in China Aster.

Table 1: Effects of micronutrients (Zn, Fe and B) on plant height (cm), number of leaves per plants, number of primary and secondary branches per plant of China aster

Notation	Treatments	Plant height (cm) 90 DAS	Number of leaves per plants 90 DAS	Number of primary branches per plants	Number of secondary branches per plants
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)	61.08	168.45	14.05	24.53
T ₂	RDF+ Iron @ 0.2%	63.23	174.91	16.70	26.68
T ₃	RDF + Iron @ 0.4%	63.55	175.43	17.46	27.00
T ₄	RDF + Iron @ 0.6%	62.44	172.26	16.14	25.49
T ₅	RDF + Zinc @ 0.2%	64.13	176.40	17.65	27.86
T ₆	RDF + Zinc @ 0.4%	64.15	178.84	18.09	28.08
T ₇	RDF + Zinc @ 0.6%	63.83	175.86	17.54	27.20
T ₈	RDF + Boron @ 0.2%	61.40	170.92	14.46	25.26
T ₉	RDF + Boron @ 0.4%	62.67	173.34	16.46	27.53
T ₁₀	RDF + Boron @ 0.6%	61.23	169.72	14.20	24.93
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%	65.62	180.57	18.60	31.10
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%	65.85	181.23	18.73	32.13
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%	65.48	179.45	18.53	30.70
SEm±		0.57	1.60	0.30	0.50
CD at 5% level		1.69	4.70	0.90	1.48

Table 2: Effects of micronutrients (Zn, Fe and B) on Plant spread (cm) and Chlorophyll content (SPAD) of China aster

Notation	Treatments	Plant spread (cm)		Chlorophyll content (SPAD)
		(N-S)	(E-W)	
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)	36.17	39.43	55.27
T ₂	RDF+ Iron @ 0.2%	39.45	41.48	56.45
T ₃	RDF + Iron @ 0.4%	39.90	42.87	56.78
T ₄	RDF + Iron @ 0.6%	39.10	42.64	55.72
T ₅	RDF + Zinc @ 0.2%	40.72	43.59	57.62
T ₆	RDF + Zinc @ 0.4%	41.35	44.74	58.64
T ₇	RDF + Zinc @ 0.6%	40.69	42.68	57.18
T ₈	RDF + Boron @ 0.2%	38.35	41.34	56.19
T ₉	RDF + Boron @ 0.4%	38.20	41.12	55.46
T ₁₀	RDF + Boron @ 0.6%	37.05	41.10	55.32
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%	43.12	45.17	59.09
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%	43.54	45.89	59.20
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%	42.78	44.67	58.98
SEm±		0.91	0.78	0.52
CD at 5% level		2.68	2.29	1.53

It is evident from the Table 2 that the effect of different micronutrient on plant spread (N-S) at 90 days after transplanting was varied from 36.17 to 43.54 cm. The maximum plant spread (N-S) (43.54 cm) was found in

treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was exhibited at par with treatment T₆ (RDF + Zinc @ 0.4%) T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @

0.6% + Boron @ 0.6%). Where as it was showed significantly differ with rest of all other treatments. The minimum plant spread (N-S) was (36.17 cm) observed with treatment T₁ control.

The plant spread (E-W) at 90 days after transplanting was varied from 39.43 to 45.89 cm. The maximum plant spread (E-W) (45.89 cm) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The minimum plant spread (E-W) was (45.89 cm) observed with treatment T₁ control.

Application of micronutrient (ZnSO₄) had a significant impact on plant spread; it encouraged cell division, proliferation, and differentiation, which boosted photosynthesis and the transfer of nutrients to the plant and enhanced plant growth and development. Additionally, the root system is strengthened, resulted in micronutrient absorption and increased water and nutrient uptake and utilization by the plant, that may be favorable to plant growth, development and plant spread. The results can by

confirm conformity of Kakade *et al.* (2009)^[14] and Joseph *et al.* (2019)^[13] in china aster.

It is evident from the table that the effect of micronutrients (Zn, Fe and B) on chlorophyll content of China aster significantly affected by application of micronutrients. The chlorophyll content was varied from 55.27 to 59.20. The maximum chlorophyll content (59.20) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The lowest chlorophyll content was (55.27) observed with treatment T₁ control.

The positive impact of micronutrients on the growth parameter may be attributed to the fact that they are a crucial component of structural and chlorophyll material. ZnSO₄ produces substantially more functioning leaves and photosynthetic that might be more accumulation of plant growth substances as well as dry matter in the plant. Similar results were also reported by Fahad *et al.* (2014)^[8] in gladiolus and Mohana *et al.* (2021)^[19] in marigold.

Table 3: Effects of micronutrients (Zn, Fe and B) on nutrient uptake of China aster

Notation	Total uptake (g per ha)		
	Zn	Fe	B
T ₁	350.42	2052.68	1168.99
T ₂	383.97	2339.86	1124.37
T ₃	390.02	2394.59	1097.21
T ₄	380.07	2416.54	1152.43
T ₅	443.36	1995.99	1120.95
T ₆	459.21	1987.39	1097.50
T ₇	457.78	2007.25	1174.48
T ₈	383.76	1943.60	1204.32
T ₉	388.03	1925.26	1231.49
T ₁₀	385.95	1829.61	1249.51
T ₁₁	447.47	2381.33	1293.23
T ₁₂	455.60	2464.32	1331.27
T ₁₃	447.04	2338.66	1267.97
SEm±	3.82	19.64	10.93
CD at 5% level	11.23	57.67	32.09

It is evident from the Table 3 that the effect of different micronutrient on total uptake zinc micronutrient was varied from 350.42 to 459.21 g/ha. The highest zinc nutrient uptake (459.21 g/ha) was found in treatment T₆ (RDF + Zinc @ 0.4%) which was at par with treatment T₇ (RDF + Zinc @ 0.6%) and T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%). However it was showed significantly differ with rest of other treatments. The lowest zinc uptake was (350.42 g/ha) observed with treatment T₁ control.

The total uptake of iron micronutrient was varied from 1829.61 to 2464.32 g/ha. The highest iron uptake (2464.32 g/ha) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was at par with treatment T₄ (RDF + Iron @ 0.6%). Where as it was showed significantly differ with rest of other treatments. The lowest iron uptake was (1829.61 g/ha) observed with treatment T₁₀ - RDF + Boron @ 0.6%.

The total uptake of micronutrient was varied from 1097.21 to 1331.27 g/ha. The highest boron nutrient uptake (1331.27

g/ha) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%). Which was showed significantly greatest with all other treatments. The lowest boron uptake was observed with treatment T₃ - (RDF + Iron @ 0.4%).

In order to increase aster crop absorption of both macro and micronutrients, That improvements in leaf and flower nutrient levels. Micronutrient application may be favorable for enzymes that regulate sugar and regulate plant growth and development also stimulate the plant's defense mechanisms. Foliar feeding of nutrients has become an established procedure and that may be increase yield and quality of produced. The results can be conformity with the finding. Through promoting root development and increasing nutrient uptake, it may actually help roots absorb the same nutrients or additional nutrient that may be favourable to plant growth and development and also improved the quality of the flowers. Similar results were also reported by Bashir *et al.* (2013)^[3].

Table 4: Effects of micronutrients (Zn, Fe and B) on days taken to first bud appearance (days), and Days to flower opening (days) and flower diameter (cm) of China aster

Notation	Treatments	Days taken to first bud appearance (days)	Days to flower opening (days)	Flower diameter (cm)
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)	89.15	101.49	5.28
T ₂	RDF+ Iron @ 0.2%	87.03	98.62	5.87
T ₃	RDF + Iron @ 0.4%	86.96	98.41	6.33
T ₄	RDF + Iron @ 0.6%	87.93	99.53	5.52
T ₅	RDF + Zinc @ 0.2%	86.70	97.14	6.49
T ₆	RDF + Zinc @ 0.4%	85.38	96.78	6.54
T ₇	RDF + Zinc @ 0.6%	86.82	97.86	6.36
T ₈	RDF + Boron @ 0.2%	88.23	100.69	5.63
T ₉	RDF + Boron @ 0.4%	87.16	99.16	5.40
T ₁₀	RDF + Boron @ 0.6%	89.47	101.13	5.32
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%	84.63	95.46	6.72
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%	84.40	95.12	6.83
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%	84.87	96.14	6.62
	SEm±	0.61	0.71	0.11
	CD at 5% level	1.79	2.10	0.32

It is evident from the Table 4 that the effect of different micronutrient on days taken to first bud appearance was varied from 84.40 to 89.15 days. The minimum days taken to first bud appearance (84.40 days) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The maximum days taken to first bud appearance was (89.15 days) observed with treatment T₁ control.

The micronutrients zinc and iron encourage the storage of more carbohydrates through photosynthesis, which may also be the cause of early blooming and the start of flower buds. The storage of additional carbohydrates through photosynthesis is favoured by micronutrients like ZnSO₄, which may promote the beginning of buds earlier. Similar result was obtained by Saini *et al.* (2015) [26] in chrysanthemum and Patokar *et al.* (2017) [24] in African marigold. Similar result was also observed by Pal *et al.*, (2016) [26] in chrysanthemum flower crop.

The days to flower opening was varied from 95.12 to 101.49 days. The minimum days to flower opening (95.12 days) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @

0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The maximum days to flower opening was (101.49) observed with treatment T₁ control.

Foliar application micronutrients like zinc promote the accumulation of more carbohydrates through photosynthesis, which may be lead to earlier flower opening. Similar results were also achieved by Thirumalmurugan, *et al.*, (2015) [28] in African marigold.

The flower diameter was varied from 5.28 to 6.83 cm. The maximum flower diameter (6.83 cm) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). Whereas it was showed significantly differ with rest of other treatments. The minimum flower diameter was (5.28 cm) observed with treatment T₁ control.

Foliar application of micronutrient, particularly association of zinc and iron regulates semi-permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which might be responsible for increased flower size and weight. Similar results were also reported by Nag and Biswas (2003) [21] in tuberose. Similar result was also observed by Joseph *et al.* (2019) [13] in chrysanthemum flower crop.

Table 5: Effects of micronutrients (Zn, Fe and B) on number of flower buds per plant, number of flowers per plants and average weight of flower (g) of China aster

Notation	Treatments	Number of flower buds per plant	Number of flowers per plants	Average weight of flower (g)
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)	28.30	25.27	2.15
T ₂	RDF+ Iron @ 0.2%	31.40	27.21	2.46
T ₃	RDF + Iron @ 0.4%	32.93	28.58	2.55
T ₄	RDF + Iron @ 0.6%	30.13	26.33	2.32
T ₅	RDF + Zinc @ 0.2%	32.40	28.80	2.77
T ₆	RDF + Zinc @ 0.4%	33.18	29.16	2.92
T ₇	RDF + Zinc @ 0.6%	32.13	28.73	2.60
T ₈	RDF + Boron @ 0.2%	29.73	25.64	2.39
T ₉	RDF + Boron @ 0.4%	31.54	26.70	2.27
T ₁₀	RDF + Boron @ 0.6%	29.60	25.36	2.17
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%	34.05	29.38	3.06
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%	34.93	29.66	3.10
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%	33.04	29.23	2.99
	SEm±	0.58	0.25	0.04
	CD at 5% level	1.70	0.74	0.13

It is evident from the Table 5 that the effect of different micronutrient on number of flower buds per plant was varied from 28.30 to 34.93. The significantly higher number of flower buds per plant (34.93) was recorded in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%). Which was showed significantly greater with rest of all other treatments. The minimum number of flower buds per plant was (28.30) observed with treatment T₁ control.

Foliar application of micronutrients might prevent chlorosis in plants, result in healthy, green leaves, and boost the creation of buds by increasing the growth hormones in plants generate that may be enhance the flower bud initiation. Similar results was also reported by Chopde *et al.*, (2016)^[5] in chrysanthemum and Vanlalruati *et al.* (2019)^[29] in chrysanthemum. The results are accordance with the finding reported by Pal *et al.* (2016)^[26] in chrysanthemum crop.

The number of flower per plant was varied from 25.27 to 29.66. The maximum number of flower per plant (29.66) was noted in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The minimum number of flower noted plant was (25.27) observed with treatment T₁ control.

The application of micronutrient may have reduced chlorosis in the plants and produced healthy, green leaves, which may be enhanced assimilate synthesis and partitioned floral development, increasing the number of flowers per plant and also boosting flower output. Similar results was also reported by Joseph *et al.* (2019)^[13] in China Aster and Chopde *et al.* (2016)^[5] in chrysanthemum.

The average weight of flower was varied from 2.15 to 3.10 g. The maximum average weight of flower (3.82 g) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was found at par with treatment T₆ (RDF + Zinc @ 0.4%), treatment T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%) and T₁₃ (RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%). However it was showed significantly differ with rest of other treatments. The minimum average weight of flower was (2.15 g) observed with treatment T₁ control.

The association of zinc, which controls the semi-permeability of cell walls, mobilises more water to the flowers, and also increases iron synthesis, which may be the cause of increased floral size and weight, that may be enhance the weight of flowers. The results can be in conformity with the result reported by Balakrishnan *et al.* (2007)^[2] in African marigold. Similar result was also observed by Joseph *et al.*, (2019)^[13] in chrysanthemum flower crop.

Table 6: Effects of micronutrients (Zn, Fe and B) on Flower yield per plant and Flower yield per ha (t) of china aster

Notation	Treatments	Flower yield per plant (g)	Flower yield per ha(t)
T ₁	Control (RDF @ 180:120:100; N, P ₂ O ₅ , K ₂ O Kg/ha)	54.33	6.03
T ₂	RDF+ Iron @ 0.2%	66.93	7.43
T ₃	RDF + Iron @ 0.4%	72.87	8.09
T ₄	RDF + Iron @ 0.6%	61.08	6.78
T ₅	RDF + Zinc @ 0.2%	79.77	8.86
T ₆	RDF + Zinc @ 0.4%	85.14	9.46
T ₇	RDF + Zinc @ 0.6%	74.69	8.29
T ₈	RDF + Boron @ 0.2%	61.27	6.80
T ₉	RDF + Boron @ 0.4%	60.60	6.73
T ₁₀	RDF + Boron @ 0.6%	55.03	6.11
T ₁₁	RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%	89.90	9.98
T ₁₂	RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%	91.94	10.21
T ₁₃	RDF + Iron @ 0.6% + Zinc @ 0.6% + Boron @ 0.6%	86.22	9.58
SEm±		1.33	0.14
CD at 5% level		3.88	0.43

It is evident from the Table 6 that the effect of different micronutrient on flower yield per plant was varied from 54.33 to 91.94 g. The maximum flower yield per plant (91.94 g) was recorded in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was showed at par with treatment T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%). However it was showed significantly differ with rest of other treatments. The minimum flower yield per plant was (54.33 g) observed with treatment T₁ control.

The flower yield was varied from 6.03 to 10.21 tons per ha. The maximum flower yield per ha (10.21 t/ha) was found in treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) which was exhibited at par with treatment T₁₁ (RDF + Iron @ 0.2% + Zinc @ 0.2% + Boron @ 0.2%). However it was showed significantly differ with rest of other treatments. The minimum flower yield per ha was (6.03 t/ha) observed with treatment T₁ control.

The improvement in flowering characteristics may be attributable to zinc and iron's beneficial role in enhancing

the translocation of carbohydrates, minerals, water, and amino acids from the site of synthesis to the storage tissue, particularly on flowers, which leads to an increase in the quantity, size, and weight of flowers. Similar results were also reported by kumar *et al.* (2009)^[18] chrysanthemum. Iron might also help in producing more food material which in turn resulted in higher assimilate synthesis and partitioning of flower growth a similar trend was in consonance with Muthumanickam *et al.* (1999)^[20] in gerbera and Nag and Biswas (2003)^[21] in tuberose.

Conclusion

- Application of Micronutrients (Zn, Fe and B) in china aster was found to be superior to plant growth characteristics in treatment T₁₂ (RDF+ Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%).
- It was found that applying (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) can better improve the flower and yield of china aster.

- On the basis of research it could be concluded that, out of 13 treatment combinations, application of micro-nutrients (Zn, Fe and B) treatment T₁₂ (RDF + Iron @ 0.4% + Zinc @ 0.4% + Boron @ 0.4%) was found to be the best for achieving the highest growth, flowering, quality and yield of China aster flower.

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