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Response of plant growth regulators and multi micronutrient on growth, yield and quality of chrysanthemum cv. Ratlam selection

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Abstract
The present experiment entitled "Interaction Response of Plant growth regulators and Multi micronutrient on Growth, Yield and Quality of Chrysanthemum cv. Ratlam Selection" was carried out at Jamuvadi Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, during October 2018 to February 2019 and October 2019 to February 2020. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) consisting two factors with three replications. The treatment comprised with five plant growth regulators and three treatments of multi micronutrient. The results indicated that the foliar application of GA_3 @ 150 ppm with multi micronutrient (grade-IV) @ 0.75% foliar spray at 30 & 45 DAT after transplanting in addition to recommended dose of fertilizers (120: 60: 60 kg/ha NPK) produced better growth and yield characters *viz*., plant height, plant spread, number of branches, stem thickness, number of flowers per plant, number of flowers per plot, weight of single flower, flower yield per plot and flower yield per hectare as well as quality characters *viz*., vase life of cut flowers, shelf life of loose flowers, *in situ* longevity of flowers, flower stalk length and flower diameter in chrysanthemum cv. Ratlam Selection.

Keywords: Chrysanthemum cv. Ratlam selection, plant growth regulators, multi micronutrient, growth, yield and quality

1. Introduction
Chrysanthemum (*Chrysanthemum morifolium* Ramat.), which occupies a prominent place in ornamental horticulture, is one of the commercially exploited flower crops belongs to the family 'Asteraceae' is one of the most wide cultivated garden flower and ranks second in popularity next to rose and referred as "Queen of the East". The name 'Chrysanthemum' is derived from the Greek words "Chrysos" means 'Garden' and "Anthos" means 'Flower'. Chrysanthemum having diploid chromosome number 2n = 18. It's native to the northern hemisphere chiefly Europe and Asia. However, it is believed that, its origin is China (Cater, 1990). Among different flowers, Chrysanthemum enjoys worldwide popularity and its flower is in great demand throughout the world. It is leading commercial flower crop, grown for cut and loose flowers and also as pot plants. It is grown in many parts in the world sowing to excellent beauty and economic values.

Today with the advancement of technology, grower's main objectives in flowers crop is perfection in the forms of plants in the quality of flowers and increase in the flower production. Various chemicals are now-a-days being tried for controlling growth and flowering of chrysanthemum with a view to have compact plants and also to stretch out or retard the rate of plant growth. In recent years scientist have given due attention to the idea of regulating plant growth as second most important factors in improving the growth, yield and quality with the application of growth regulators in various ways. The view of present experiment is to maximize flower production and to regulate the flower production as per market demands.

Among all the micronutrients which affect plant growth, Zinc and iron plays a major role in plant growth and development. These micronutrients affect the growth of plants in term of vegetative growth, flower yield and quality. The possible effects of multi micronutrients formulations on flower yield are abundantly in the literature supported by the results of in marigold, China aster, gerbera and gladiolus *etc*.

Growth regulators are used in plant small quantity enhanced plant physiological process greatly which may help greatly increased the yield and quality. Gibberellic acid increased to be very effect in manipulating growth, flowering production and quality in chrysanthemum. The gibberellins are wide spread and ubiquitous in flowering and non-flowering plant. GA_3 enhances the vegetative growth and yield, also increases cell elongation and cell division, promotes delayed senescence, help to breaks seed dormancy, promotes initiation of root, stimulates flowering (Davies, 1995) [7]. It conjointly affects the growth of intact plants of the many species specially dwarfs or biennials within the rosette stage, stimulates mobilization of foods and minerals components and GA_3 is effective in reducing the juvenility period required for flowering. Gibberellic acid (GA_3) has been accustomed to increase the length or height of plants, increases the number of flowers and enhances/promotes the quality of flowering (Medina and Saavedra, 2005). Auxin plays a crucial role in cell enlargement of stem and coleoptiles. They stimulate cell division. It can initiate flowering (for example in pineapple). Apical dominance is often enhanced by its application. It certainly increases the plasticity of the cell membrane. Salicylic acid is a messenger molecule regulating developmental process and helps in management of the biotic and abiotic stresses (Zarghami *et al.*, 2014) [35]. It additionally inhibits ethylene synthesis and delays fruit senescence (Kademi and Ershadi, 2013) [15]. Further, responses of environmental stresses in plants is also modulated by salicylic acid (Yao and Tian, 2004; Supapvanich and Promyou, 2013; Ramtin *et al*., 2015) [26, 32, 34]. Brassinosteroids (BR) increase the cell division, cell elongation, root development, stem elongation, vasculature differentiation and cellulose biosynthesis. Major role of BR is the positive regulation of cell expansion. BR's modulate plant responses to biotic and abiotic stresses and to alternative phytohormones and influence differentiation processes of cell and tissues. It gives response against both biotic and abiotic stress, including salt, drought, temperature extremes and pathogens. It stimulates seed germination, vascular differentiation and apical dominance.

Similarly micronutrients in small quantities influence the growth, flowering the, as well as the quality of produce in flower crops among the micronutrients zinc, favours the storage of more carbohydrates through photosynthesis which may be the attributing factor for plants as well as early flowering. Zinc is involved in the biosynthesis of plant and reduces auxin content through its involvement in the synthesis of tryptophan a precursor of auxin and marigold absorb zinc in ionic form (Kumar *et al.*, 2010 and Balakrishnan *et al.*, 2007) [18, 19, 29, 33]. Boron has primarily involved in a structural role, especially in cell walls. Boron deficiencies also influence cellulose synthesis. It causes a change in the growth of the cells and tissue including a shift in the orientation of a cell division, inhibition of cell growth and altered tissue growth.

Copper is essential for mitochondrial respiration and photosynthesis, for nitrogen and carbon metabolism, for oxidative stress protection and is required for cell wall synthesis, to name only a few of its cellular tasks. Manganese is important for chlorophyll formation for photosynthesis, mitochondrial respiration, nitrate assimilation and for the activity of many enzymes. It is moderately mobile in plant tissues, so symptoms appear on younger leaves first, most often in those leaves just reaching their full size. Iron is a key element in various redox reactions of respiration, photosynthesis and reduction of nitrates and sulphates. As redox-active metal, it is involved in photosynthesis, mitochondrial respiration, nitrogen assimilation, hormone biosynthesis production and scavenging of reactive oxygen species, osmoprotection and pathogen defence (Hansch and Mendal, 2009) [11].

2. Materials and Methods

The field experiment was carried out twice during October 2018 to February 2019 and October 2019 to February 2020 at the Jamuvadi Farm, Department of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat, India). The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) consisting two factors with three replications.

The treatment comprised of five treatments of plant growth regulators *viz.*, Without plant growth regulators (P_0), GA_3 @ 150 ppm (P_1), NAA @ 200 ppm (P_2), SA @ 100 ppm (P_3), Brassinosteroid @ 1.5 ppm (P_4) and three treatments of multi micronutrient *i.e*. Without multi micronutrient (M_0), multi micronutrient (grade-IV) @ 0.5% (M_1) and multi micronutrient (grade-IV) @ 0.75% (M_2). Five plants from each treatment plot were randomly selected, labelled and used for recording observations. The transplanting was done at spacing of 45 x 45 cm distance and having a plot size 6.08 m^2. The recommended dose of manures and fertilizers were applied in the experimental field. The field was irrigated before transplanting. 30 days old seedlings of chrysanthemum were transplanted in the experimental plots in the morning hours. Immediately after transplanting the field was lightly irrigated for better establishment of the seedlings. The imposing of treatments were done at 30 and 45 days after transplanting. The growth attributes such as plant height, plant spread, number of branches, stem thickness and yield attributes include number of flowers per plant, number of flowers per plot, weight of single flower, flower yield per plot and flower yield per hectare as well as quality characters include vase life of cut flowers, shelf life of loose flowers, *in situ* longevity of flowers, flower stalk length and flower diameter was recorded in five selected plant per replication in each treatment. The data pertaining to various parameters were subjected to statistical analysis following the method of analysis of variance for randomized block design as per Panse and Sukhatme (1985) [23].

3. Results and Discussion

Performance of vegetative growth, yield and quality attributes of chrysanthemum cv. Ratlam Selection are given in table 1, 2 and 3.

Table 1: Effect of plant growth regulators and multi micronutrient on growth parameters in chrysanthemum cv. Ratlam selection

Treatment combination	Plant height (cm)			Plant spread (cm)			Number of branches per plant			Stem thickness (mm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Level of plant growth regulators (P)												
P_0	40.56	41.38	40.97	26.95	26.53	26.74	14.90	14.60	14.75	2.53	2.45	2.49
P_1	49.13	46.90	48.01	33.32	32.89	33.10	19.37	19.04	19.21	2.83	2.77	2.80
P_2	46.98	45.32	46.15	32.04	31.72	31.88	18.10	17.96	18.03	2.77	2.75	2.76

P_3	44.76	43.96	44.36	30.15	29.87	30.01	17.06	16.79	16.92	2.66	2.46	2.56
P_4	45.46	44.55	45.00	31.16	30.45	30.81	17.27	16.97	17.12	2.72	2.61	2.66
S.Em.±	1.24	1.09	0.83	0.82	0.92	0.62	0.35	0.35	0.25	0.05	0.06	0.04
C.D. at 5%	3.60	3.16	2.34	2.39	2.68	1.76	1.00	1.01	0.70	0.15	0.17	0.11
Level of multi micronutrient (M)												
M_0	43.40	42.54	42.97	28.63	28.15	28.39	15.70	15.67	15.69	2.64	2.56	2.60
M_1	45.93	44.96	45.45	31.39	31.10	31.24	17.70	17.41	17.55	2.69	2.66	2.67
M_2	46.80	45.75	46.28	32.16	31.62	31.89	18.61	18.13	18.37	2.76	2.61	2.68
S.Em.±	0.96	0.84	0.64	0.64	0.72	0.48	0.27	0.27	0.19	0.04	0.04	0.03
C.D. at 5%	2.79	2.45	1.81	1.85	2.07	1.36	0.78	0.78	0.54	NS	NS	NS

Table 2: Effect of plant growth regulators and multi micronutrient on yield parameters in chrysanthemum cv. Ratlam selection

Treatment combination	Number of flowers per plant			Number of flowers per plot			Weight of single flower (g)			Flower yield per plot (kg)			Flower yield per hectare (t)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Level of plant growth regulators (P)															
P_0	57.02	56.18	56.60	610.44	575.56	593.00	2.61	2.59	2.60	1.49	1.30	1.39	6.08	5.29	5.68
P_1	80.33	78.24	79.29	825.11	785.78	805.44	3.63	3.60	3.61	2.21	1.99	2.10	9.06	8.16	8.61
P_2	76.13	72.11	74.12	792.33	748.89	770.61	3.51	3.47	3.49	2.13	1.83	1.98	8.72	7.50	8.11
P_3	70.49	65.64	68.07	726.89	694.44	710.67	3.23	3.21	3.22	1.79	1.64	1.72	7.36	6.72	7.04
P_4	74.27	69.84	72.06	771.56	731.67	751.61	3.48	3.43	3.45	2.09	1.71	1.90	8.57	7.00	7.78
S.Em.±	1.44	1.67	1.10	13.75	15.93	10.52	0.06	0.06	0.04	0.06	0.04	0.04	0.24	0.17	0.15
C.D. at 5%	4.18	4.83	3.12	39.89	46.14	29.81	0.18	0.18	0.13	0.17	0.12	0.10	0.69	0.48	0.41
Level of multi micronutrient (M)															
M_0	65.63	60.61	63.12	687.40	648.00	667.70	3.09	3.05	3.07	1.82	1.50	1.66	7.45	6.13	6.79
M_1	73.12	70.40	71.76	763.13	726.13	744.63	3.37	3.36	3.36	1.94	1.73	1.84	7.97	7.10	7.53
M_2	76.20	74.20	75.20	785.27	747.67	766.47	3.40	3.38	3.39	2.06	1.85	1.96	8.44	7.57	8.01
S.Em.±	1.12	1.29	0.85	10.65	12.34	8.15	0.05	0.05	0.03	0.04	0.03	0.03	0.18	0.13	0.11
C.D. at 5%	3.24	3.74	2.42	30.86	35.74	23.09	0.14	0.14	0.10	0.13	0.09	0.08	0.54	0.37	0.32

Table 3: Effect of plant growth regulators and multi micronutrient on quality parameters in chrysanthemum cv. Ratlam selection

Treatment combination	Vase life of cut flowers (days)			Shelf life of loose flowers (days)			*In situ* longevity of flowers (days)			Flower stalk length (cm)			Flower diameter (cm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Level of plant growth regulators (P)															
P_0	5.38	5.29	5.33	3.19	3.17	3.18	9.76	10.00	9.88	12.83	13.40	13.12	5.30	5.15	5.23
P_1	6.47	6.29	6.38	4.12	4.02	4.07	12.44	12.56	12.50	16.00	16.38	16.19	5.90	5.81	5.85
P_2	6.17	6.02	6.09	3.97	3.79	3.88	11.91	12.08	12.00	15.39	15.52	15.46	5.80	5.69	5.75
P_3	6.01	5.78	5.89	3.65	3.66	3.66	10.84	11.06	10.95	14.70	14.33	14.51	5.60	5.47	5.54
P_4	6.10	5.91	6.00	3.76	3.75	3.76	11.47	11.53	11.50	14.74	15.32	15.03	5.58	5.66	5.62
S.Em.±	0.16	0.15	0.11	0.13	0.10	0.08	0.38	0.45	0.29	0.58	0.52	0.40	0.14	0.16	0.11
C.D. at 5%	0.45	0.42	0.30	0.39	0.28	0.23	1.11	1.29	0.83	1.68	1.52	1.11	NS	NS	0.31
Level of multi micronutrient (M)															
M_0	5.79	5.61	5.70	3.46	3.48	3.47	10.49	10.72	10.61	13.77	14.00	13.89	5.37	5.29	5.33
M_1	6.07	5.89	5.98	3.84	3.75	3.80	11.52	11.63	11.57	15.09	15.26	15.18	5.74	5.64	5.69
M_2	6.22	6.07	6.14	3.91	3.81	3.86	11.84	11.99	11.91	15.34	15.70	15.52	5.80	5.73	5.77
S.Em.±	0.12	0.11	0.08	0.10	0.07	0.06	0.30	0.35	0.23	0.45	0.41	0.30	0.11	0.13	0.08
C.D. at 5%	NS	0.33	0.23	0.30	0.22	0.18	0.86	1.00	0.65	1.30	1.18	0.86	0.32	0.37	0.24

3.1 Effect of plant growth regulators

Different plant growth regulators significantly increased all the vegetative growth parameters as compared to without plant growth regulator (Table 1). Plants treated with treatment P_1 - GA_3 150 ppm showed highest plant height (49.13, 46.90 & 48.01 cm), plant spread (33.32, 32.89 & 33.10 cm), number of branches per plant (19.37, 19.04 & 19.21) and stem thickness (2.83, 2.77 & 2.80 mm) at 120 DAT during the year 2018-19, 2019-20 as well as in pooled, respectively while these parameters were minimum with the treatment of without plant growth regulator.

The increase in vegetative growth due to GA_3 might also be due to stimulation of cell division and cell elongation, promotion of protein synthesis coupled with dry matter accumulation while increasing plasticity of cell wall and formation of energy rich phosphates. GA_3 might increase the auxin content in tissue as it was involved in auxin synthesis and greater amount of carbohydrate by accumulation which increased metabolic activities. Stimulation of branching may be possible due to the breakage of apical dominance. GA_3 was known to influence translocation and transcription mechanism of protein biosynthesis, thus resulting in increased plant height, plant spread, stem thickness with more number of reproductive branches. This is in conformity with the results of Gupta and Datta (2001) [10], Gautam *et al.* (2006) [9], Shinde *et al.* (2010) [27], Alhajhoj (2017) [2] and Singh *et al.* (2018) [1, 19, 28, 29] in chrysanthemum.

The treatment P_1 - GA_3 150 ppm recorded the maximum number of flowers per plant (80.33, 78.24 & 79.29), number of flowers per plot (825.11, 785.78 & 805.44), weight of single flower (3.63, 3.60 & 3.61 g), flower yield per plot (2.21, 1.99 & 2.10 kg) and flower yield per hectare (9.06, 8.16 & 8.61 t) during both the years as well as in pooled analysis. The large number of lateral production at early stage of

growth leads to the enhancement in number of flowers per plant. It might be due to getting sufficient time to accumulate carbohydrate for sufficient and proper flower bud differentiation resulted in enhanced reproductive efficiency and photosynthesis restrictive plant type (Sunitha *et al*. 2007) [31]. GA_3 responsible for continuous supply of food at the time of flowering from the higher number of branches. The increase in yield and yield parameters with GA_3 spray to responsible for continuous supply of food at the time of flowering from the better crop growth, higher number of branches, leaves and leaf area, which might have boosted the production and accumulation of assimilates that were translocated from source to sink for flower production and more number of flowers per plant and plot and maximum weight of single flower thus ultimately increased the flower yield plant and plot. These results are confirmed by those reported by Gupta and Datta (2001) [10], Gautam *et al*. (2006) [9], Moond and Gehlot (2006) [20], Aklade *et al*. (2009) [1], Dalal *et al*. (2009), Patel *et al*. (2010) [24, 27] in chrysanthemum.

It is evident from the data (Table 3) that the different plant growth regulators had significant effect on various quality parameters over without plant growth regulators. Maximum vase life of cut flowers (6.47, 6.29 & 6.38 days), Shelf life of loose flowers (4.12, 4.02 & 4.07 days), *In situ* longevity of flowers (12.44, 12.56 & 12.50 days), flower stalk length (16.00, 16.38 & 16.19 cm) and flower diameter (5.85 cm) were also recorded treatment application of GA_3 150 ppm. The present findings for maximum flower diameter and stalk length are in accordance with findings of Tyagi and Kumar (2006) [18, 19, 29, 33]; they observed that the foliar spray GA_3 at 200 ppm at 30 days after planting get the maximum flower diameter and stalk length in African marigold cv. Pusa Narangi Gainda.

These results might be due to the fact that gibberellic acid might be responsible for the continuous supply of food from leaves at the time of flowering leading to longer vase life of chrysanthemum. GA_3 increased flower which increased stored food material in the tissue, which cause increase in vase life of flower, shelf life of flower and *in situ* longevity of flower. Gibberellic acid improve overall yield and quality parameter by virtue of cell elongation and production of maximum food material by enhancing photosynthesis, which might have produce higher yield with good quality flowers, which in turn might have helped flowers to last longer in vase life, shelf life and *in situ* longevity.

Flower diameter and number of ray florets per flower are the characters which significantly contributes the yield. The flower diameter differed significantly due to growth regulator spray. However GA_3 150 ppm recorded maximum flower diameter and number of ray florets per flower might be due to increased strength of the actively growth parts.

The increment in stalk length might be due to an increase in the length of branch. Increase in stalk length due to the translocation of photosynthates to the flower as a consequence of intensification of the sink and also due enhanced cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter of apical dominance (Dalai *et al*. 2009). The results of present study are in close conformity with findings of Padmapriya and Chezhiyan (2002) [21] and Patel *et al*. (2010) [24, 27] in chrysanthemum.

3.2 Effect of multi micronutrient

Application of multi micronutrient (grade-IV) @ 0.75% (M_2) significantly influenced various vegetative growth, yield as well as quality attributes of chrysanthemum cv. Ratlam Selection (Table 1, 2 & 3).

The application of multi micronutrient (grade-IV) @ 0.75% (M_2) treatment resulted in maximum plant height (46.80, 45.75 & 46.28 cm), plant spread (32.16, 31.62 & 31.89 cm) and more number of branches per plant (18.61, 18.13 & 18.37), highest number of flowers per plant (76.20, 74.20 & 75.20), number of flowers per plot (785.27, 747.67 & 766.47), weight of single flower (3.40, 3.38 & 3.39 g), flower yield per plot (2.06, 1.85 & 1.96 kg), flower yield per hectare (8.44, 7.57 & 8.01 t), Vase life of cut flowers (6.07 & 6.14 days), Shelf life of loose flowers (3.91, 3.81 & 3.86 days), *In situ* longevity of flowers (11.84, 11.99 & 11.91 days), Flower stalk length (15.34, 15.70 & 15.52 cm) and Flower diameter (5.80, 5.73 & 5.77 cm) during the year 2018-19, 2019-20 as well as in pooled data. The similar increase in vegetative growth due to application of 0.8% ferrous sulphate was recorded by Ganga *et al*. (2008) [8, 18] in chrysanthemum.

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) [12].

Increase in plant growth due to iron that acts as an important catalyst in the enzymatic reactions of the metabolism and would have helped in larger biosynthesis of photo assimilates thereby enhancing growth of the plants. These are component of many enzymes associated with energy transfer, nitrogen reduction and fixation and lignin formation. Iron is associated with sulfur in plants to form compounds that catalyze other reactions. Iron deficiency is common in alkaline soil with typical chlorosis; the young leaves turning yellowish with veins remaining green. Iron application increased the leaves of all leaf pigments, but the extent of increase in level depend on the pigment affected (Srivastava and Singh, 2003) [1, 19, 28, 29]. Copper is of utmost importance for life. 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). These finding are in agreement with the finding of Ganga *et al*. (2008) [8, 18], Saini *et al*. (2015) and Chopde *et al*. (2016) [5, 25] in chrysanthemum; Balakrishnan *et al*. (2005), Jat *et al*. (2007) [14] and Subhash (2015) [30] in African marigold; Kakade *et al*. (2009) [1, 16] in China aster; Pal (2011) [22] in Gerbera.

Significantly maximum number of flowers per plant, number of flowers per plot, weight of single flower, flower yield per plant, flower yield per plot and flower yield per hectare were registered with an application of multi micronutrient (grade-IV) @ 0.75% (M_2) during both the years as well as in pooled data.Iron is great importance for life of plant. As redox-active metal, it is involved in photosynthesis, mitochondrial respiration, nitrogen assimilation, hormone biosynthesis (ethylene, gibberellic acid, jasmonic acid), production and scavenging of reactive oxygen species, osmoprotection and pathogen defense (Hansch and Mendal, 2009) [11]. Zinc is important as a component of enzymes for protein synthesis and energy production and maintains the structural integrity of bio membranes. Zinc plays an important role in seed development and zinc deficient plants show delayed maturity. Zinc is required for the synthesis of auxin IAA and for carbohydrate metabolism, protein synthesis, internode elongation for stem growth and pollen formation (Shukla *et*

al. 2009) [28]. Zn^{2+} ions at low concentration (0.01 ppm) slightly enhance the activity of tryptophan synthesis leading to biosynthesis of auxin (Horak *et al*. 1976) [13].

The possible effect of multi micronutrients formulation on flower yield also supported by the results of Ganga *et al*. (2008) [8, 18], Kumar *et al*. (2009) [18, 19, 29, 33], Saini *et al*. (2015) and Chopde *et al*. (2016) [5, 25] in chrysanthemum; Balakrishan (2005) [3], Jat *et al*. (2007) [14], Kumar *et al*. (2010) [18, 19, 29, 33], Subhash (2015) [30] and Patokar *et al*. (2017) [25] in marigold; Kakade *et al*. (2009) [1, 16] in China aster; Pal (2011) [22] in gerbera.

Multi micronutrient increased storage life of chrysanthemum. Longer shelf life may be due to higher retention of water in the cells of flowers and low flower desiccation caused due to the beneficial effect of multi micronutrient. It might be due to plants receiving required iron and zinc in an optimum proportion could have resulted in increased the internal storage of iron and zinc content which was also responsible for shelf life of loose flower because iron and zinc work as catalyst in chlorophyll synthesis thus it create favorable condition inside the stem and gives it the strength against adverse condition after harvest. Furthermore, these findings are well supported by Ganga *et al*. (2008) [8, 18], Kumar *et al*. (2009) [18, 19, 29, 33], Saini *et al*. (2015) and Chopde *et al*. (2016) [5, 25] in chrysanthemum; Balakrishan (2005) [3] and Subhash (2015) [30] in marigold; Kakade *et al*. (2009) [1, 16], Khosa *et al*. (2011) and Pal (2011) [22] in China aster.

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