

**Response of standard chrysanthemum
(*Dendranthema grandiflora* Tzvelev) to micronutrient
sprays in the Malwa region of Madhya Pradesh**

THESIS



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In

HORTICULTURE

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by

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Mandsaur (M.P.) - 458001

2017

CERTIFICATE - I

This is to certify that the thesis entitled “**Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh**” submitted in partial fulfillment of the requirements for the Degree of Master of science in **HORTICULTURE** in the department of **Floriculture and Landscape Architecture** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-side research work carried out by **Mr. MANISH KUMAR VERMA**, under my guidance and supervision. The subject of the thesis has been approved by the student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of these investigations has been acknowledged by the scholar.

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CERTIFICATE - II

This is to certify that the thesis entitled “**Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh**” submitted by **Mr. MANISH KUMAR VERMA**, to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in **HORTICULTURE** in the department of **Floriculture and Landscape Architecture** has been accepted after evaluation by the External Examiner and approved by the Student’s Advisory Committee after an oral examination on the same.

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Place: Mandsaur

Date: .../.../.....

(Manish Kumar Verma)

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List of Abbreviations/Symbols

Symbol	Abbreviation	Stands for
%		Percentage
&		And
/		Per
-	⁰ C	Degree Celsius
-	ANOVA	Analysis of variance
-	B:C	Benefit cost ratio
-	C.D.	Critical difference
-	Cm	Centimetre
-	Cv	Cultivar
-	d.f.	Degree of Freedom
-	DAP	Days After Planting
-	DAP	Days After transplanting
-	<i>et al.</i>	And others/ associates
-	Etc.	Etcetera
-	Fig.	Figure
-	CRD	Completely Randomized Design
-	G	Gram
-	ha.	Hectare
-	Kg	Kilogram
-	M	Metre
-	m ²	Metre square
-	i.e.	That is
-	M.P.	Madhya Pradesh
-	M.S.S.	Mean sum of squares
-	Max.	Maximum
-	Min.	Minimum
-	No.	Number
-	NS	Non significant
-	R.H.	Relative humidity
-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
-	SE(m) ±	Standard Error of Mean
-	Sig.	Significant

-	spp.	Species
-	Var.	Variety
-	Viz.	(videlicet) Namely
-	q./ha	Quintal Per Hectare
-	RH	Relative Humidity
-	Spp.	Species
-	Var.	Variety
-	Viz	(Videlicet) Namely

Chapter-I

INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) Syn. *Chrysanthemum morifolium* Ramat is an important commercially exploited flower crop belonging to the family 'Asteraceae', comprising of about 200 species and is known as "Queen of East and Glory of East". It is commonly known as 'Gaul e Dhaudi' and 'Sevanti' in Hindi and Gujrati, respectively. It is native to the northern hemisphere and is widely distributed in Europe and Asia. However, it is believed that, its origin is China (Carter, 1980).

Japan, China, Holland, France, England, America and India are now the major commercially chrysanthemum producing countries. In India, the area under chrysanthemum is around 18.38 thousand ha with production of 175.67 MT of loose flowers (Anonymous, 2013). The commercial cultivation of flowers is presently confined to West Bengal, North Eastern States, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Rajasthan.

Its cultivation has expanded in non- traditional area also. There is ample scope to enhance the productivity of chrysanthemum by adopting proper crop management techniques. In order to meet the ever increasing demand on production of quality flowers, to increase productivity and to overcome the physiological disorders, application of major and micronutrients is inevitable.

Nowadays, micronutrients especially zinc and iron are gradually gaining momentum among the flower growers because of their beneficial nutritional support and to ensure better harvest and returns. A suitable micronutrient dose, period and method of application will certainly improve the production and quality of flower crops (Gurav *et al.*, 2004).

The quality of chrysanthemum flowers is influenced by application of micronutrients. Although required in smaller quantities, they are essential for crop growth and development. In recent past, micronutrients are gradually gaining momentum among the flower growers because of their beneficial nutritional support as well as their potential to ensure high yield with better quality.

Considering the popularity of chrysanthemum and its potential for capturing markets, there is an urgent need to address this important aspect of quality flower production in chrysanthemum in India.

Micronutrients play important roles in plant nutrition. Most of them are used in the functioning of a number of enzyme systems. However, there is considerable variation in the specific function of the various micronutrients in plants and in the microbial growth processes. Nowadays micronutrients are gradually gaining momentum among the flowers for their beneficial nutrient support and at the same time to ensure better harvest and returns (Balakrishna *et al* 2017). Micronutrients assist in nitrogen assimilation and synthesis of proteins. Micronutrients have a great bearing in influencing the yield attributes and flower production. Application of micronutrients is found to enhance the foliage and flower production.

Iron and zinc deficiency can be corrected by application Fe and Zn sources to soil or foliar sprays. Foliar sprays of ferrous sulphate and zinc sulphate or chelates are found to be more effective and efficient than soil application in flowers and several other crops. Fertilizer requirement for basal soil application of Fe and Zn is very high compared to foliar application of ferrous sulphate and zinc sulphate solution and as such soil application is uneconomical. Iron and zinc chelates are more efficient than inorganic sources in combating iron and zinc deficiency but due to high cost of synthetic carriers, farmers do not prefer using chelate (Singh, 2004).

Boron is known to promote cell division, protein metabolism and salt absorption. Boron is also associated with root formation (Naik *et al* 2008). Most boron is taken up by plants passively as boric acid (H_3BO_3). Once taken in to leaves, boron tends to be immobile in most plant species and is not translocated from older to younger leaves to any great extent. The role of boron in plant metabolism is not fully understood but includes maintenance of cell membrane and transport of other nutrients through them. Keeping in view the above facts a study entitled “Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh” was conducted with following objectives:

1. To study the effect of micronutrients on the vegetative growth of standard chrysanthemum.
2. To study the effect of micronutrients on the flowering of standard chrysanthemum.

3. To study the effect of micronutrients on biochemical parameters associated with growth and flowering of standard chrysanthemum.

CHAPTER – II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the research work done so far in India and abroad by different workers on the effect of micronutrients on growth and flowering of Chrysanthemum and other important commercial flowers and ornamentals and related aspects have been briefly reviewed and presented in chronological order under the following headings:

2.1 Growth parameters.

2.2 Flowering parameters.

2.3 Biochemical parameters.

2.1 Growth parameters.

A study was conducted on the foliar application of growth chemicals (F₀; control, F₁; Wuxol; F₂; Vegimax, F₃; Agro grow and F₄; Surgrow) with 3 replications. The tallest plant (38.2 cm) and the maximum number of leaves (31.6) were recorded from F₂ and the shortest plant (31.4cm) and the minimum number of leaves (21.3) were recorded from F₀. Application of surgrow increased the petal brightness but vegimax was found suitable for growth and yield of chrysanthemum.

(Jamal uddin *et al.*, 2011).

A field experiment was carried out to study the effect of zinc and iron on growth, yield and quality of chrysanthemum. Various biometric observations were taken on growth and physiological parameters viz., plant height, stem girth, number of branches, leaves per plant and leaf area. The results revealed that the treatment combination of 0.5% zinc sulphate +0.5% ferrous sulphate was found to be the best in growth, yield and quality attributes followed by 0.5% zinc sulphate +0.75% ferrous sulphate and 0.5% zinc sulphate +0.25% ferrous sulphate.

(Karuppaiah, 2014).

Tarachand *et al.*, (2015) conducted an experiment on the effect of micronutrients (Fe and Zn) on growth and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. IIHR – 6. Growth was influenced by different levels of ferrous sulphate.

The maximum plant height at 60 DAT (56.11 cm) and 90 DAT (72.33 cm), plant spread in N-S (30.67 cm) and E-W (22.67 cm), leaf area (37.11 cm²), number of suckers per plant (20.33), fresh weight (306.67 g) and dry weight (35.44 g) of plant were obtained at FeSO₄ @ 0.8 per cent (F₄). In case of different levels of ZnSO₄, the maximum plant height at 60 DAT (53.67 cm) and 90 DAT (70.33 cm), leaf area (35.33 cm²), number of suckers per plant (18.33), fresh weight (297.50 g) and dry weight (33.00 g) of plant were obtained at ZnSO₄ @ 0.5 per cent (Z₃).

Dahlia

In an experiment on the effect of micronutrients on dahlia cv. Swami Lokeshwarananda, it was observed that Zn stimulated maximum plant height, stem diameter, green leaves, its area and branching. Zn + B + Fe + Mn was the best combination recorded.

(Khan, 2000).

Gerbera

Khosa et al., (2011) conducted an experiment to study the effect of foliar application of Zn, B and Fe on the vegetative growth superiority of gerbera. Micronutrient solutions containing 5000±200, 4000±200 and 5000±200 mg/of Zn, B and Fe were used. Different concentration of micro nutrients i.e. 12.5ml+ 987.5ml water, 18.75ml+981.25ml water and 25ml+975ml water taken and sprayed fifteen days intervals on potted gerbera. Spray of different solution micronutrients was also being applied at constant rate of 5ml/1000 ml of water. Plant height, number of branches per plant, length of branches per plant, number of leaves per plant and leaf area increased with micronutrient application.

Marigold

Jat et al., (2007) conducted an experiment to study the effect of foliar application of urea and zinc sulphate (0.0, 0.5, 1.0 and 1.5 %) on growth parameters in African marigold (*Tagetes erecta* Linn.). The results revealed that foliar application of zinc sulphate @ 0.5 percent was found to be the most effective to obtain better growth of African marigold.

Kumar et al., (2010) reported that the growth parameters were significantly influenced by different levels of iron. The maximum plant height (74.73 cm), number of branches/plant (49.77) and number of leaves/plant (306.00) were recorded at 150 ppm iron spray at 15 and 30 days after transplanting as compared to the control. All the growth parameters significantly increased by application of iron because iron plays an important role in chlorophyll synthesis, photosynthesis and respiration.

An experiment was conducted to check the response of marigold (*Tagetes erecta* L.) to spray of zinc (Zn) on growth of marigold. Marigold plants were sprayed with five levels of zinc sulphate (0, 0.3, 0.5, 0.7 and 0.9%). Results revealed that most of the traits were significantly affected by zinc while leaf area showed non-significant differences. It was concluded that 0.5% of zinc should be sprayed for good vegetative growth of marigold.

(Shah et al.,2016).

Zinnia

In a study on the effect of micronutrients as a foliar spray on the performance of Zinnia (*Zinnia elegans*) Liliput mix, it was observed that maximum height of plant, number of leaves/plant, diameter of shoots, length of longest leaf and width of leaves were obtained under 1500 ppm each of Zinc and iron treatment combination.

(Singh and Kumar, 2009).

Carnation

An experiment was conducted to study the influence of different foliar fertilizer contains macro - elements (20%N, 20% P, 20% K, 0.12% Mg) and micro - elements (70 ppm Fe, 14 ppm Zn, 16 ppm Cu, 42 ppm Mn, 72ppm B and 24 ppm Mo) on the growth, analysis of leaves of *Dianthus caryophyllus* cv. "Red Sim". The foliar fertilizer was applied 5 times during the growing period. The results revealed that plant treated with foliar nutrition showed significant increase in the growth characteristics (stem length , stem diameter, stem fresh and dry weight, number of leaves/ plant, fresh and dry weight of leaves) compared to the untreated plants (control).

(Aly et al.,2008).

Gladiolus

Chopde et al. (2013) studied the effect of foliar application of zinc and iron on growth, yield and quality of gladiolus. The treatments comprised of different levels of zinc (control i.e. water spray, 0.2%, 0.4% and 0.6%) and iron (control i.e. water spray 0.2%, 0.4% and 0.6%). The results revealed that foliar application of 0.4% zinc and 0.4% iron recorded significantly maximum vegetative growth in respect of plant height and leaf area, yield in respect of spikes plant⁻¹ and corms plant⁻¹.

Nerium

In a study on the effect of foliar application of iron and Zinc on growth of nerium (*Nerium odorum* L.) cv. Pink Double, it was observed that maximum plant height, number of secondary branches, number of leaves plant, plant spread and leaf area were recorded with 0.75 % FeSO₄ + ZnSO₄ treatment combination.

(Kumar and Haripriya., 2010).

Rose

Kode et al. (2015) conducted a field trial to study the effect of sprays of micro nutrients viz. MgSO₄, MnSO₄, FeSO₄, B, ZnSO₄ and CuSO₄ at different concentrations on growth, of rose cv. Sophia Loren. The study revealed that all micronutrient sprays increased the plant height, plant spread, leaf area, shoot growth rate and number of shoots significantly.

Flowering parameters

In study on the effect of micro-nutrients on flowering of *chrysanthemum morifolium* cv. Chandrama, it was observed that maximum flower stalk length was recorded at 200 ppm Zn and highest diameter of flower and maximum number of flower at Mn 200ppm

(Barman and Pal.,1999).

Ganga et al. (2008) studied the response of chrysanthemum cv. CO 1 to the application of micronutrients. The earliest flowering, longest flowering duration, highest number of flowers /plant, flower stalk length, flower diameter and vase life of flowers were recorded with 0.8% iron.

A field experiment was carried out to study the effect of zinc and iron on flower yield and quality of chrysanthemum. Various biometric observations on flowering and yield attributes viz., number of flowers per plant, flower stalk length, flower head diameter, flower head weight, flower yield per plant and hectare and quality attributes were recorded. The results revealed that the treatment combination of 0.5% zinc sulphate +0.5% ferrous sulphate was found to be the best in flowers, yield and quality attributes followed by 0.5% zinc sulphate +0.75% ferrous sulphate and 0.5% zinc sulphate +0.25% ferrous sulphate.

(Karuppaiah , 2014).

Dahlia

Khan (2000) studied the effect of micronutrients on dahlia cv.Swami Lokeswarananda. It was observed that earlier flowering, maximum number of flowers, flower diameter and stalk length were recorded with Zn + B + Fe + Mn over the control ones.

Marigold

Studies on effect of micro-nutrients on flowering, flower yield and xanthophyll content in African marigold (*Tagetes erecta* Linn.) hybrid L3 were conducted during 2004-2005 in monsoon and winter seasons. The results revealed that spraying of plants with 0.5% zinc sulphate +0.5% ferrous sulphate recorded the early flowering (48.01 and 39.78 day)

(Balakrishnan et al.,2007),

Kumar et al. (2010) reported that the flowering parameters were significantly influenced by different levels of iron. The minimum days taken to 1st flower bud appearance (49.47 days), number of flowers/plant (20.33) diameter of flower (5.40 cm), length of flower stalk (13.30 cm) and yield of flower heads (194.97 q/ha) were recorded at 150 ppm iron spray at 15 and 30 days after transplanting as compared to the control.

Gupta et al. (2015) conducted an experiment with ten treatments comprising of 3 levels each of ZnSO₄ (0.2, 0.4, 0.6 %), CuSO₄ (0.2, 0.4, 0.6 %) and FeSO₄ (0.2, 0.4, 0.6 %) replicated thrice to evaluate the effect of micro-nutrients on flowering attribute and yield characters in African marigold. Among all the treatments CuSO₄ (0.4 %) resulted in the early flower bud initiation, opening of first flower, maximum duration of flowering and maximum number of flower per plant, stalk length, flower weight, yield of flower per plant and flower yield per hectare were observed with spray of ZnSO₄ (0.4%).

Nerium

In a study on the effect of foliar application of iron and zinc on the flowering and yield of nerium (*Nerium odorum* L.) cv. Pink Double, it was observed that significant and superior result on early flowering, duration of flowering and yield attributes like flower diameter, hundred flower weight, flower yield /plant, flower yield /pot and estimated flower yield per hectare were observed with FeSO₄ at 0.75% +ZnSO₄ at 0.50% spray.

(Kumar and Haripriya., 2010)

Orchid

In a study on the effect of micronutrients on the yield and quality of the orchid *Dendrobium* cv. Soniya 17, it was observed that the number of spikes per plant, number of florets/spike length, flower pedicel length and vase life were significantly increased with recommended dose of NPK (20:20:10) + ZnSO₄ 1000ppm.

(Ganga et al., 2009).

Rose

In a study on the response of micronutrient spray on flowering, flower quality and yield of Raktagandha rose, increased flower production with delayed flowering and bud length was recorded with spray of 1.00%ZnSO₄.

(Bhattacharjee and Singh.,1992).

Tulip

In a study on the effect of NPK and Zn on flowering and production in tulip under polyhouse condition in Kashmir valley, it was observed that combined

application of N, P, K and Zn @75, 50, 50 and 5 kg /ha, respectively was found to be the most suitable dose obtaining better, quality flower and bulb production.

(Khan *et al.*,2006).

Biochemical Analysis

Chrysanthemum

Markus *et al.*, (1983) studied the effect of growth and composition of chrysanthemum by various levels of Mn in peat substrate. It was observed that the no-Mn and no-Fe treatment, as well as in the micronutrient treatments, foliar concentration of Mn and Fe decrease to about 10 to 20% respectively. The concentration of Zinc in the no-zinc and no- micronutrient substrate treatments was 18 and 100% respectively.

Gerbera

Muthumanickam *et al.*, (1999) studied the effect of leaf nutrient content in gerbera. Among the treatments spraying of 0.2% each of $MnSO_4+FeSO_4+ZnSO_4$ recorded the highest amount of Fe (80.3ppm), Mn (98.4ppm) and Zn (79.3ppm) during the 12 months of spraying.

Marigold

Balakrishna *et al.*, (2007) studied the effect of micro-nutrients on flowering, flower yield and xanthophyll content in African marigold (*Tagetes erecta* Linn.) Hybrid L3, The plants sprayed with 0.5% ferrous sulphate recorded the highest total leaf chlorophyll content (1.965 mg) in monsoon season and 0.5% zinc sulphate + 0.5% ferrous sulphate recorded the highest leaf chlorophyll content (2.135 mg) in winter season. Zinc sulphate 0.5% + ferrous sulphate 0.5% + sodium molybdate 0.02% and ferrous sulphate 0.5% + sodium molybdate 0.02% recorded the highest xanthophyll content of 2.419 & 100 g and 1.896 & 100g in monsoon and winter season respectively.

Anthurium

Paswan *et al.*, (2010) studied the growth and flowering of anthurium (*Anthurium andreaeanum*) cv. Cherry Red as influenced by boron application. It was observed that boron uptake by flower and plant were significantly influenced by

higher concentration of boron (2mg) showing 1.16mg/m² (flowers) and 3.2mg/m² (plant) of boron respectively. Anthocyanin content increased with increasing concentration of boron.

Gladiolus

In an experiment on the response of pre-harvest micronutrient foliar spray on leaf nutrient content in gladiolus, foliar feeding each of FeSO₄ and ZnSO₄ 0.5% concentration significantly influenced iron and zinc content in the leaves.

(**Pratap et al., 2005**).

In a study on the effect of micronutrients on leaf nutrient content in gladiolus cv. American Beauty, higher Zinc content (25.14mg/L) in leaf was observed with 300g/l Zinc.

(**Naik et al., 2008**).

Tuberose

In a study on the effect of Zinc on leaf nutrient content in tuberose (*Polianthes tuberosa* L.) cv. Double, Zinc content (48.74ppm) was observed at 20kg level of Zinc content

(**Yadav et al.,2002**).

In a study on the effect of nitrogen and zinc application in tuberose (*Polianthes tuberosa*) cv. Double it was observed that zinc content in leaves increased progressively with the application of different doses of zinc. The maximum zinc content (57.5ppm) was recorded when 10ppm zinc was applied.

Kumar et al., (2004).

Chapter-III

MATERIALS AND METHODS

The experimental materials and criteria used for treatment evaluation during the course of investigation are being presented in this chapter. The experiment entitled: “Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh” was conducted during the period from September 2016 to January 2017. Details of the method and techniques utilized in the experiment are given below.

3.1: Experimental Site

The experiment was laid out at the K.N.K. College of Horticulture, Mandsaur (M.P.) during September 2016 to January 2017. Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.45⁰ to 24.13⁰ and 74.44⁰ to 75.18⁰ East longitudes and an altitude of 435.02 meters above mean sea level. This region falls under Agro climatic zone no.10 of the state.

3.2: Climate of the Region

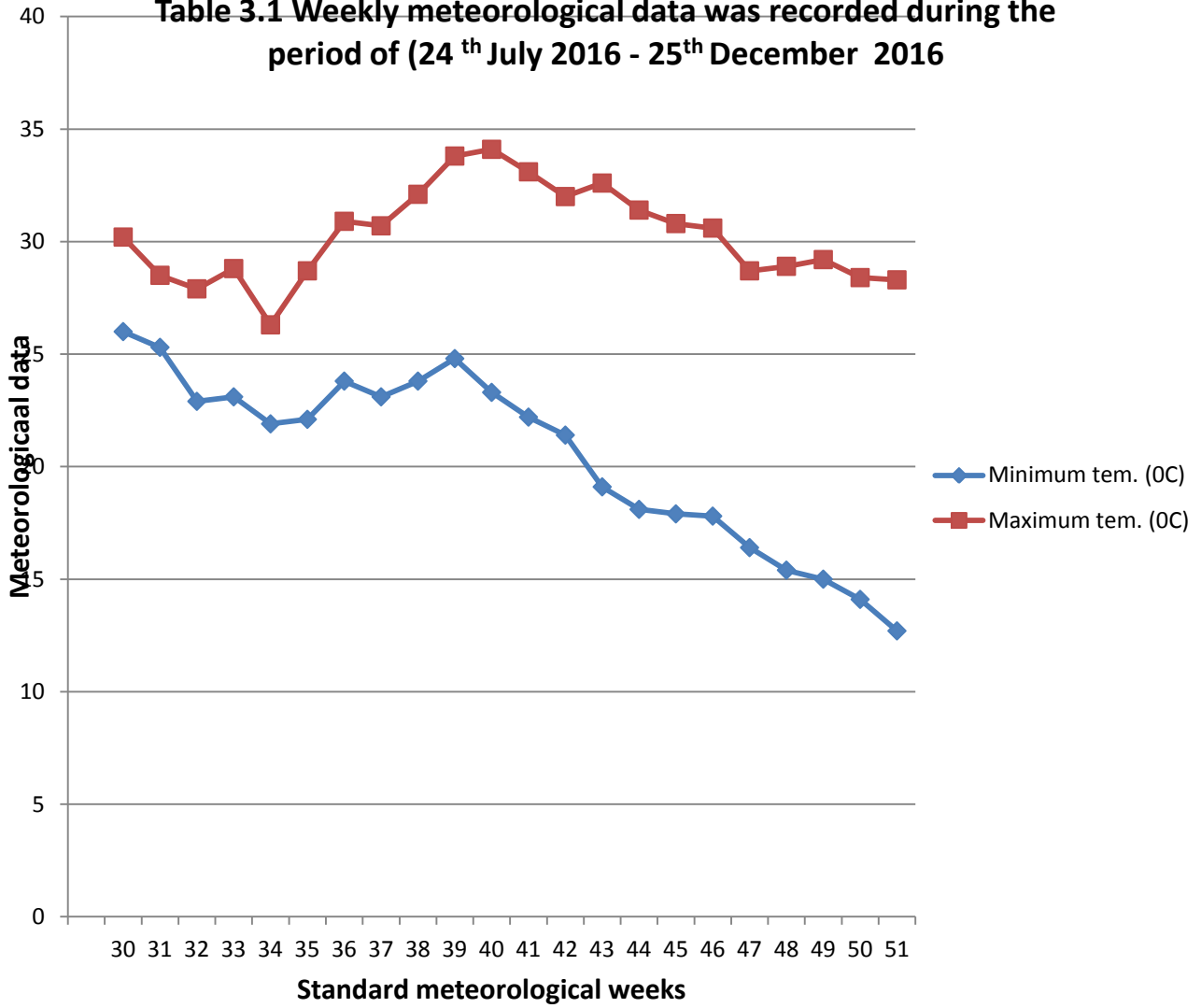
Mandsaur belongs to sub-tropical climate having a temperature range of minimum 5⁰C and maximum 44⁰C in winter and summer, respectively. In this area, most of the rainfall is received during mid June to mid September with occasional showers in winter. South-west monsoon is responsible for major portion of annual precipitation. The average rainfall is 544.05 mm. Meteorological data recorded during the period of investigation are presented in table 3.1 and are graphically shown in fig 3.1.

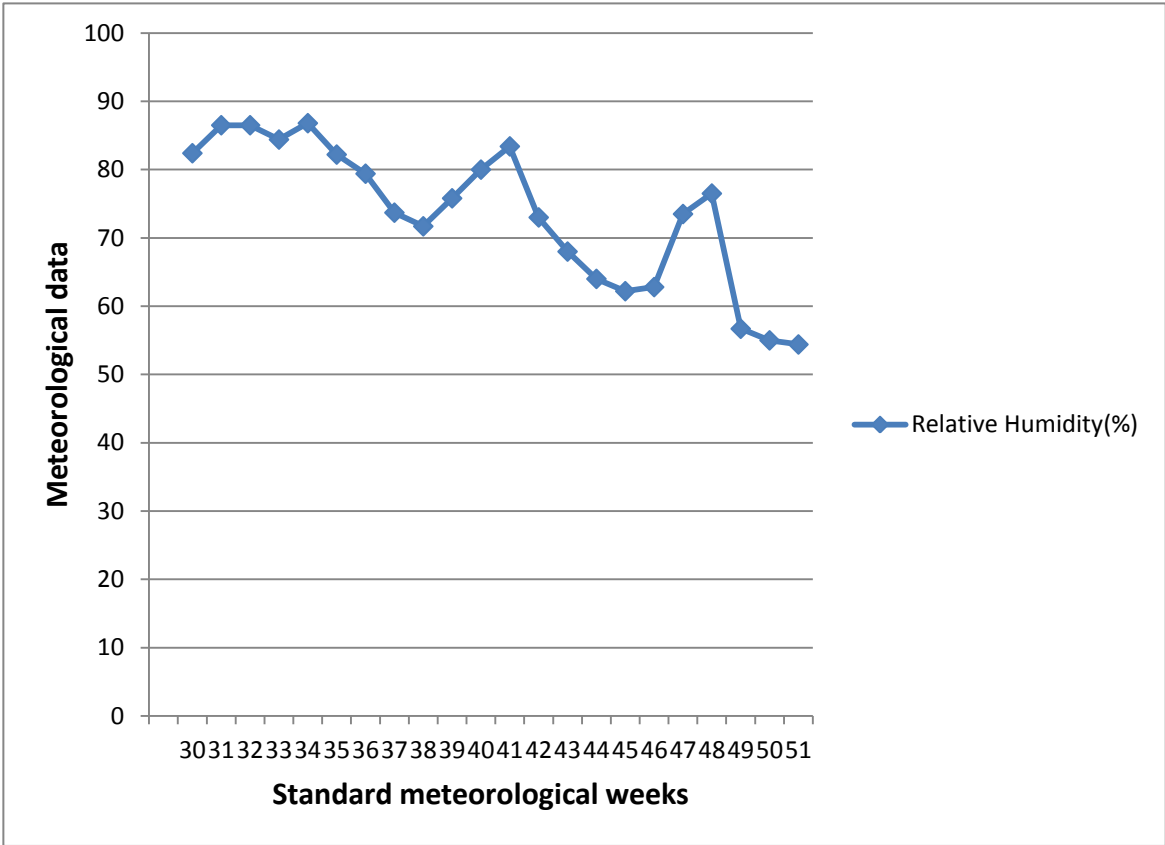
Table3.1: Weekly meteorological data was recorded during the period of (24th July 2016 – 25nd December 2016)

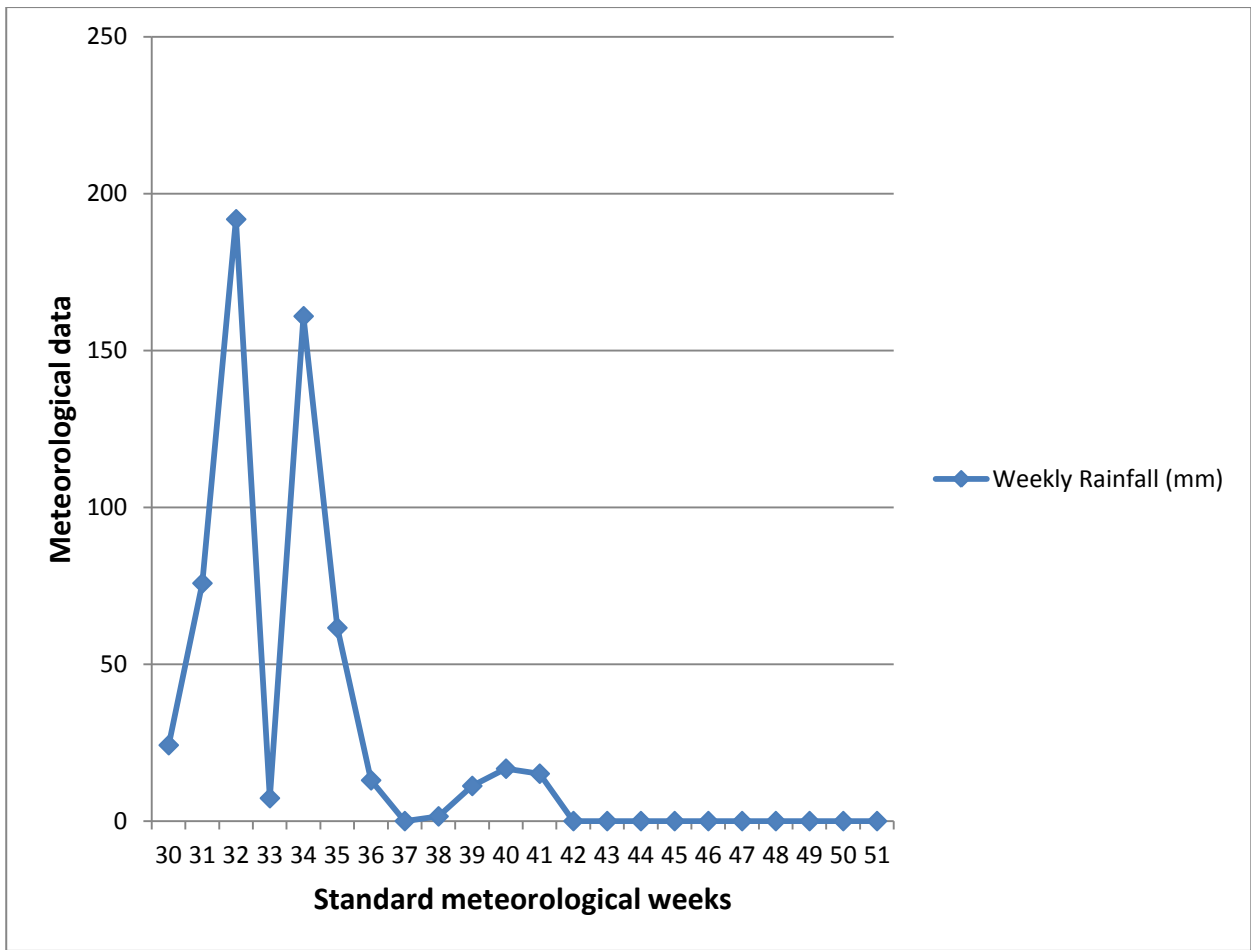
Standard metrological weeks	Average weekly Temperature		Relative Humidity (%)	Weekly Rainfall (mm)
	Min. (°C)	Max. (°C)		
30	26.0	30.2	82.4	24.2
31	25.3	28.5	86.5	75.8
32	22.9	27.9	86.5	191.8
33	23.1	28.8	84.4	7.3
34	21.9	26.3	86.8	160.9
35	22.1	28.7	82.2	61.6
36	23.8	30.9	79.4	13.0
37	23.1	30.7	73.7	-
38	23.8	32.1	71.7	1.5
39	24.8	33.8	75.8	11.2
40	23.3	34.1	80.0	16.7
41	22.2	33.1	83.4	15.1
42	21.4	32.0	73.0	-
43	19.1	32.6	68.0	-
44	18.1	31.4	64.0	-
45	17.9	30.8	62.2	-
46	17.8	30.6	62.8	-
47	16.4	28.7	73.5	-
48	15.4	28.9	76.5	-
49	15.0	29.2	56.7	-
50	14.1	28.4	55.0	-
51	12.7	28.3	54.4	-

Source: Meteorological observatory of the K.N.K. College of Horticulture, Mandasaur (M.P.)

Table 3.1 Weekly meteorological data was recorded during the period of (24th July 2016 - 25th December 2016







3.2: Experimental Details

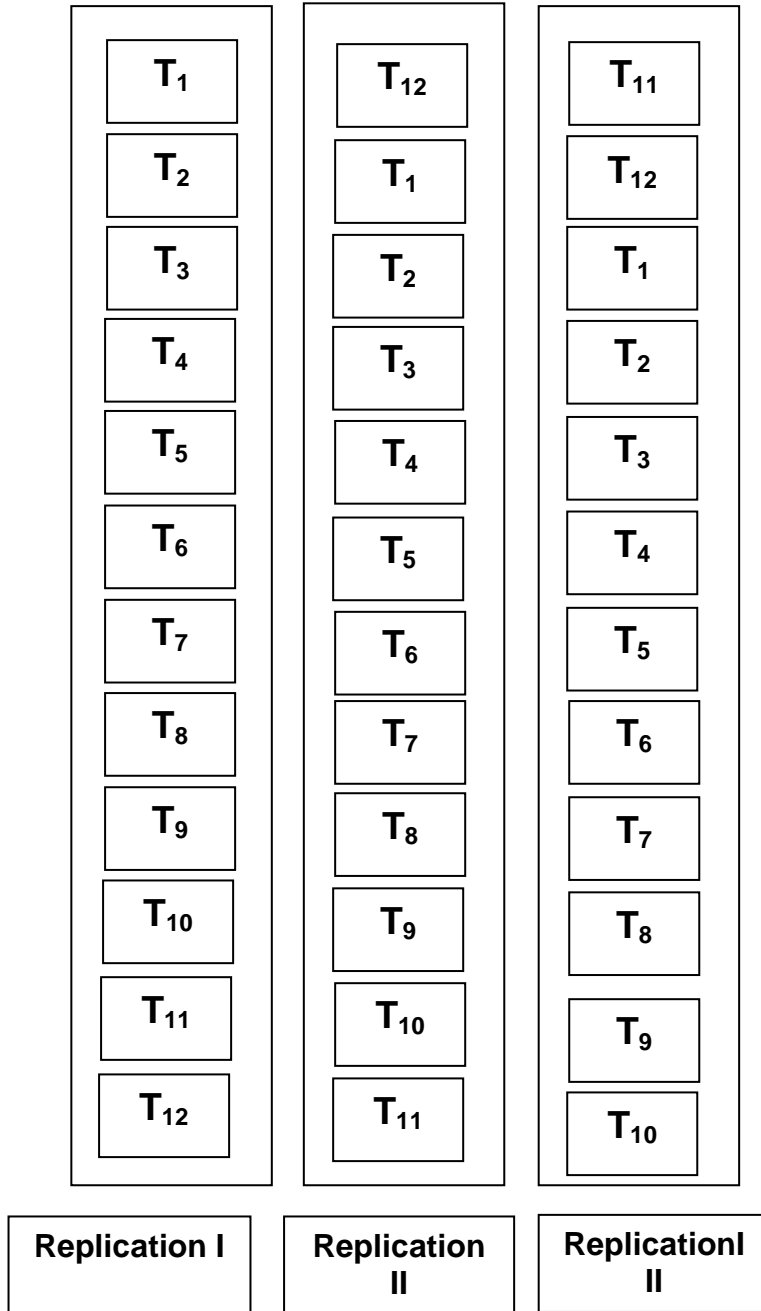
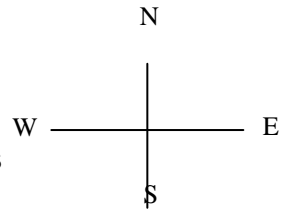
	Particulars	Details
1.	Location	K.N.K. College of Horticulture Mandsaur (M.P.)
2.	Name of crop	Chrysanthemum (<i>Dendranthema grandiflora</i> Tzvelev)
3.	Name of variety	Hybrid – 1
4.	Season	Kharif season 2016-17
5.	Experimental design	Completely Randomized Design
6.	Number of Treatments	12
7.	Number of Replications	03
8.	Number of plant per replicate	03
9.	Number of plants per treatment	09
10.	Total number of plants	108
11.	Total number of pots	108
12.	Date of planting	28 August 2016
13.	Micronutrient application	28 September 2016

3.3: Treatment details

S.No.	Symbol	Treatments
1.	T ₁	Control
2.	T ₂	0.50% ZnSO ₄
3.	T ₃	0.75% ZnSO ₄
4.	T ₄	0.50% FeSO ₄
5.	T ₅	0.75% FeSO ₄
6.	T ₆	0.2% Borax
7.	T ₇	0.50% ZnSO ₄ +0.50% FeSO ₄
8.	T ₈	0.50% ZnSO ₄ +0.75% FeSO ₄
9.	T ₉	0.75% ZnSO ₄ +0.50% FeSO ₄
10.	T ₁₀	0.75% ZnSO ₄ +0.75% FeSO ₄
11.	T ₁₁	0.75% ZnSO ₄ +0.50% FeSO ₄ +0.2% Borax
12.	T ₁₂	0.50% ZnSO ₄ +0.75% FeSO ₄ +0.2% Borax

3.4: Experimental design and layout

The description of design and layout is as follows



3.5: Pot operations

3.5.1 Preparation of pots

Proper drainage system was maintained in pots. The drainage hole at the bottom of pots was loosely covered with small bricks and stones before filling media. One month old stem cuttings of *Dendranthema grandiflora* were transplanted in the centre of pot in the month of September. Soil was firmly pressed around the plant and light watering was done immediately.

3.5.2: Pot filling

The pots were filled by the medium (Soil: Sand: Vermicompost - 1:1:1) @ 5 kg/ pot.

3.5.3: Planting

A healthy rooted terminal cutting was planted in each pot. Before planting the terminal cuttings were dipped in bavistin 3g/litre of water, for 15 minutes. The terminal cuttings were planted at the centre of the pots. Immediately after planting, watering was done and pots were kept in shade net house.

3.5.4: Care and Management of the plants

Recommended dose of manures and fertilizers were applied. The plants were irrigated once a week during the period from September to January . Weeding, hoeing etc were also carried out from time to time.

3.5.5 Pinching

Pinching was done at 30 days after planting. The soft vegetative shoot tips 1.5 to 3 cm long were removed.

3.5.6 De-Suckering

De-Suckering operation was done time to time for proper and vigorous growth of plants.

3.5.7 Staking of plants

Staking was necessary to keep the plants erect and to maintain proper shape of plants. Stakes were prepared from wooden sticks

3.5.8: Plant protection

The medium was drenched with chlorpyrifos 3ml/l of water at 15 days after planting for termite control. At 30 days after planting the medium was drenched with carbendazim 3g/l of water for protection from fungi. . To prevent aphid infestation the plants were sprayed with Malathion 2ml/l & dimethoate 3ml/l of water

3.5.9: Harvesting

Flowers were harvested when the outer ray florets were completely elongated and two rows of disc florets were completely developed. They were harvested with the help of secateurs and kept in fresh water immediately after harvesting. A uniform stalk length of 30 cm was maintained for the experiment.

Observations to be recorded

3.6.1 Growth parameters

3.6.1.1. Plant height (cm)

The plant height was measured from ground level to the growing tip of the plant with the help of measuring scale and average was worked out. Height of the randomly selected and tagged plant was measured at 30,45 and 60 days after planting.

3.6.1.2. Number of leaves per plant

The number of leaves per plant was counted in randomly selected and tagged plants at 45 days after planting.

3.6.1.3. Fresh weight of shoot (g)

Shoots were cut from the plant and weighed with the help of electronic balance. The weight of such fresh shoot was recorded at 45 days after transplanting and at harvest.

3.6.1.4. Dry weight of shoot (g)

Fresh shoot from randomly selected plants were weighed, dried in oven at 65° C temperature till constant weight. The weight of such dried shoot was recorded at 45 days after planting and at harvest.

3.6.2 Flowering parameters

3.6.2.1. Days taken for first flower appearance

The number of days from planting to the date of first flower opening was counted and recorded in the different treatments.

3.6.2.2. Flower diameter (cm)

The diameter of the flower was measured by using a centimetre scale.

3.6.2.3. Stalk length (cm)

Stalk length was measured with the help of metre scale in cm.

3.6.2.4. Weight of individual flower (g)

Flowers were cut from the plants and weighed with the help of electronic balance.

3.6.2.5. Vase life of flowers (days)

The cut flowers were discarded when one-third of the petals were brown or wilted, the number of days taken for this was recorded as vase of the cut flowers.

3.6.3 Biochemical Analysis:

3.6.3.1. Chlorophyll content in leaves (SPAD value):

Chlorophyll content in leaves was estimated by using instrument SPAD chlorophyll meter by simple clamping the meter over leafy tissue.

3.6.3.2. Pigment content in petals (mg/100g)

Estimation of anthocyanin

Anthocyanins are the most important and widespread groups of colouring matters in plants. These intensely coloured water-soluble pigments are responsible for nearly all colours in leaves, petals and fruits of higher plants. They are based chemically on a single aromatic structure, that of cyanidin and all are derived from this pigment by addition or by subtraction of hydroxyl groups or by methylation or by glycosylation. There are six common anthocyanidins (anthocyanin aglycones, formed when anthocyanins are hydrolyzed with acid) which differ in the nature of the sugar (often glucose, but may also be galactose, rhamnose, xylose or arabinose), the number of sugar units (mono-, di- or tri-glycosides) and the position of attachment of sugar (usually to the 3'-hydroxyl or to the 3'- and 5'-hydroxyl).

Principle

The alcohol extract of the sample is treated with HCl in aqueous methanol followed by anthocyanin reagent. The colour intensity is measured colorimetrically at 525nm.

Reagents

1. Alcohol
2. 0.5N HCl in 80-85% methanol (HCl in aqueous methanol).
3. Anthocyanin reagent: Mix 1 ml of 30% H_2O_2 with 9ml of methanolic HCl (5:1, 3N).

Method

1. Grind a known weight of fresh flower petals in alcohol.
2. Filter or centrifuge and collect the extract.
3. Pipette 1 ml of the alcohol extract into the test tube and add 3ml of HCl in aqueous methanol.
4. Add 1 ml of anthocyanin reagents to the samples.
5. Prepare the blank in the same manner by adding 1ml of methanol- HQ instead of anthocyanin reagent.
6. After 15 min of incubation in the dark, measure the absorbance at 525nm against the blank.
7. Calculate the amount of anthocyanins present in the sample from a standard curve prepared with cyanin hydrochloride.

Notes

1. 10μ of cyanin hydrochloride/ml in methanol-HCl = absorbance or 0.405 in a 1.0 cm cell at A_{525} .
2. Alternatively, the anthocyanin content may be expressed as A_{525} values.

3.6.3.3. Leaf nutrient content

Material required:

Dried plant, H₂SO₄, HClO₄ double distilled water, williymill, funnels Wathman filter paper grade1, volumetric flask, measuring cylinders, pipettes, AAS(Hitachi Z-2300) etc,

Procedure

1. Dried plant were harvested. The root portion was removed and plants were dried in hot air oven on 75⁰ C for 24 hours.
2. Dried samples were ground in willymill and dried powder was used for analysis.
3. 1g dried powder was digested in di-acid mixture 15 ml (H₂SO₄:HClO₄, 4:1) at the temperature of 350-400⁰C using Kel-plus KES -12 furnace,
4. .After complete digestion the digested extract was diluted with double distilled water up to 50 ml.
5. Diluted extract was analysed for micro-nutrient on AAS(Hitachi Z2300)

3.7.4 : Statistical Analysis:

Experimental data of the study entitled “Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient spray in the Malwa region of Madhya Pradesh” were recorded and statistically analyzed using the method of Analysis of variance as described by Fisher, (1956) in his book “Design of Experiments.”

The analysis of variance has been given in appendix and the skeleton of analysis of variance is presented in table (3.3).

The ‘F’ test was applied to judge the overall significance of various treatments in general and comparison of individual treatment was made with the help of critical difference at 5% level of significance, which was calculated as given in the table (3.2).

Table 3.3: The skeleton of analysis of variance

Source of variance	DF	SS	MSS	Fc	Ft 5%
Treatment	11	SS(t)	SS(t)/8	SS(V)/ {SS(E)/18}	
Error	24	SS(E)	SS(E)/18		
Total	35	SS(T)			

$$\text{S.Em. } \pm = \sqrt{\frac{2 \text{ EMS}}{R}}$$

$$\text{CD} = \text{S.Em. } \pm \times \sqrt{2} \times t_{5\% (\text{edf})}$$

Where

EMS : Error mean sum of squares

R : Replications

t_{5%} : Table value at error degree of freedom

S.Em. ± : Standard error of mean

CD : Critical difference

Chapter – IV

RESULTS

The results of the experiment entitled “Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrients sprays in the Malwa region of Madhya Pradesh” have been presented in this chapter. The data pertaining to various characters were subjected to statistical analysis by using CRD. In support of the tabular representation of data, graphical presentation has also been presented in this chapter to provide better comprehension of the characters.

4.1 Growth parameters

4.1.1 Plant height (cm) at 30, 45 and 60 days after planting

It can be observed from Table 4.1 and Fig. 4.1 that the effect of micronutrients on plant height (cm) was statistically significant during all the stages of observation (at 30, 45 and 60 DAP).

At 30 DAP the maximum plant height (46.77cm) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄+0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+0.75% FeSO₄+0.2% Borax) and T₉ (0.75% ZnSO₄+0.50% FeSO₄), which recorded values of 45.20 cm and 44.53 cm respectively. The minimum plant height (40.20cm) at this stage was recorded by T₁ (control).

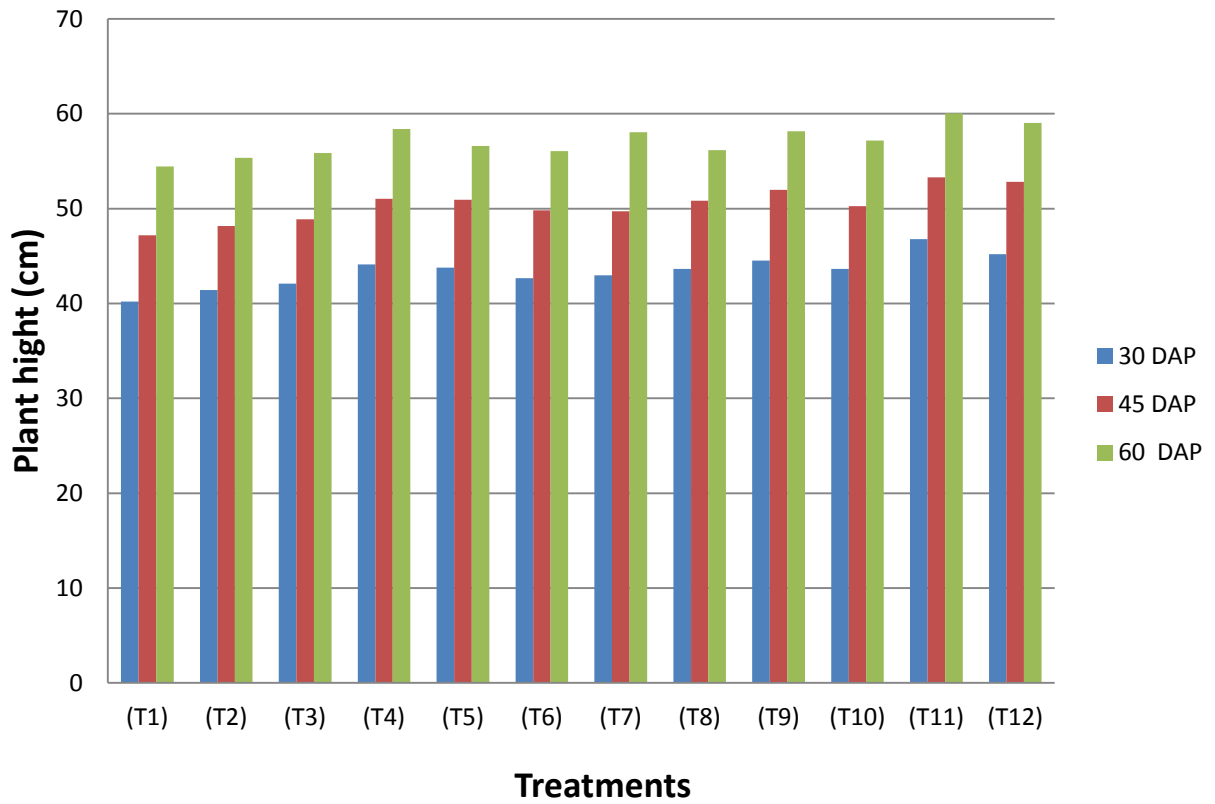
A similar trend was observed at 45 DAP with T₁₁ (0.75% ZnSO₄+0.50% FeSO₄+0.2% Borax) recording the maximum plant height (53.30cm) followed by T₁₂ (0.50% ZnSO₄+0.75% FeSO₄+0.2% Borax), and T₉ (0.75% ZnSO₄+0.50% FeSO₄) which recorded values of 52.83 cm and 51.97 cm respectively. The minimum plant height (47.20 cm) at this stage was recorded by T₁ (control).

At 60 DAP also a similar trend was observed with T₁₁ (0.75% ZnSO₄+0.50% FeSO₄+0.2% Borax) recording the maximum plant height (60.03 cm) followed by T₁₂ (0.50% ZnSO₄+0.75% FeSO₄+0.2% Borax), and T₉ (0.75% ZnSO₄+0.50% FeSO₄) which recorded values of 59.03 cm and 58.17 cm respectively. The minimum plant height at this stage (54.43cm) was recorded by T₁ (control).

Table 4.1 Plant height (cm)

Treatment	30 DAP	45 DAP	60 DAP
(T ₁)	40.20	47.20	54.43
(T ₂)	41.43	48.17	55.37
(T ₃)	42.10	48.87	55.87
(T ₄)	44.13	51.03	58.40
(T ₅)	43.77	50.93	56.60
(T ₆)	42.67	49.83	56.07
(T ₇)	42.97	49.73	58.07
(T ₈)	43.63	50.83	56.17
(T ₉)	44.53	51.97	58.17
(T ₁₀)	43.63	50.27	57.17
(T ₁₁)	46.77	53.30	60.03
(T ₁₂)	45.20	52.83	59.03
S.Em.	0.93	0.89	0.81
CD(5%)	2.72	2.60	2.35

Fig 4.1 Effect of micronutrient sprays on plant height (cm)



4.1. 2. Number of leaves per plant

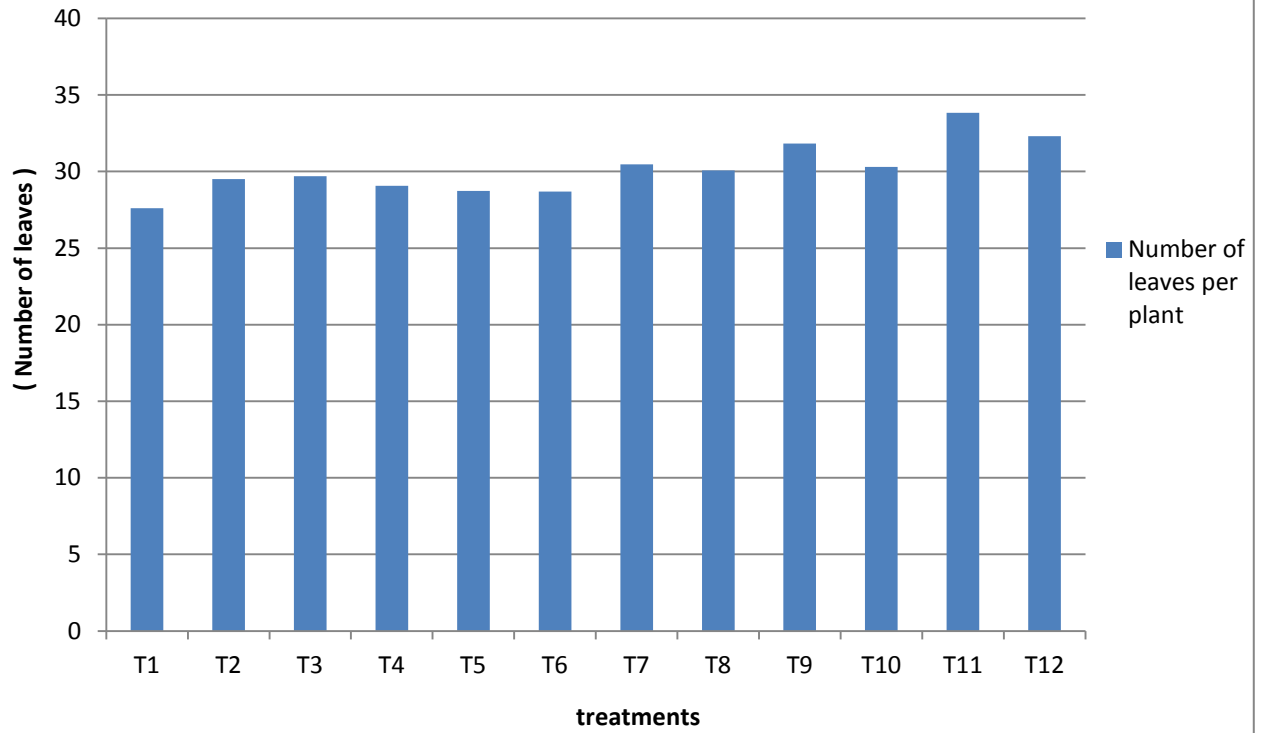
It can be observed from Table 4.2 and Fig. 4.2 that the effect of micronutrients on number of leaves per plant was statistically significant at 45 DAP.

At 45 DAP the maximum number of leaves per plant (33.83) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) which recorded values of 32.30, 31.83 and 30.47 respectively. The minimum number of leaves per plant (27.60) at this stage was recorded by T₁ (control).

Table 4.2 Number of leaves per plant at (45) DAP

Treatment	Number of leaves per plant
(T ₁)	27.60
(T ₂)	29.50
(T ₃)	29.70
(T ₄)	29.07
(T ₅)	28.73
(T ₆)	28.70
(T ₇)	30.47
(T ₈)	30.07
(T ₉)	31.83
(T ₁₀)	30.30
(T ₁₁)	33.83
(T ₁₂)	32.30
S.Em.	0.65
CD(5%)	1.89

Fig. 4.1.2. Effect of micronutrient sprays on number of leaves per plant 45 DAP



4.1.3 Fresh weight of shoots (g) at 45 DAP

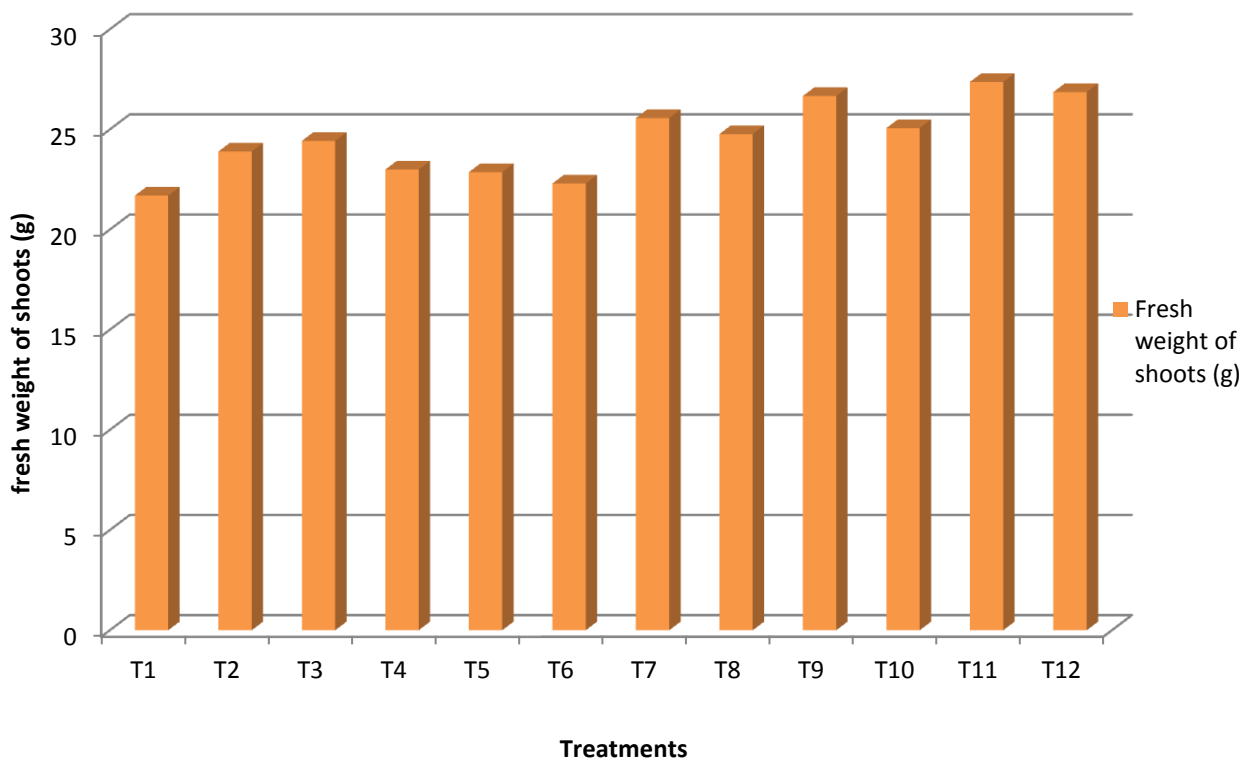
It can be observed from Table 4.3 and Fig. 4.3 that the effect of micronutrients on fresh weight of shoots (g) was statistically significant during stages of observation at 45 DAP.

At 45 DAP the maximum fresh weight of shoots (27.37g) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75% FeSO₄) which recorded values of 26.87g, 26.67g, 25.57g, 25.07g and 24.77g respectively. However, these treatments were statistically at par with one another. The minimum fresh weight of shoots (21.20g) at this stage was recorded by T₁ (control).

Table 4.3 Fresh weight of shoots (g) at 45 DAP

Treatment	Fresh weight of shoots (g)
(T ₁)	21.70
(T ₂)	23.90
(T ₃)	24.43
(T ₄)	23.00
(T ₅)	22.87
(T ₆)	22.30
(T ₇)	25.57
(T ₈)	24.77
(T ₉)	26.67
(T ₁₀)	25.07
(T ₁₁)	27.37
(T ₁₂)	26.87
S.Em.	0.78
CD(5%)	2.27

Fig. 4.3. Effect of micronutrient sprays on fresh weight of shoots 45 DAP



4.1.4 Dry weight of shoots (g) at 45 DAP

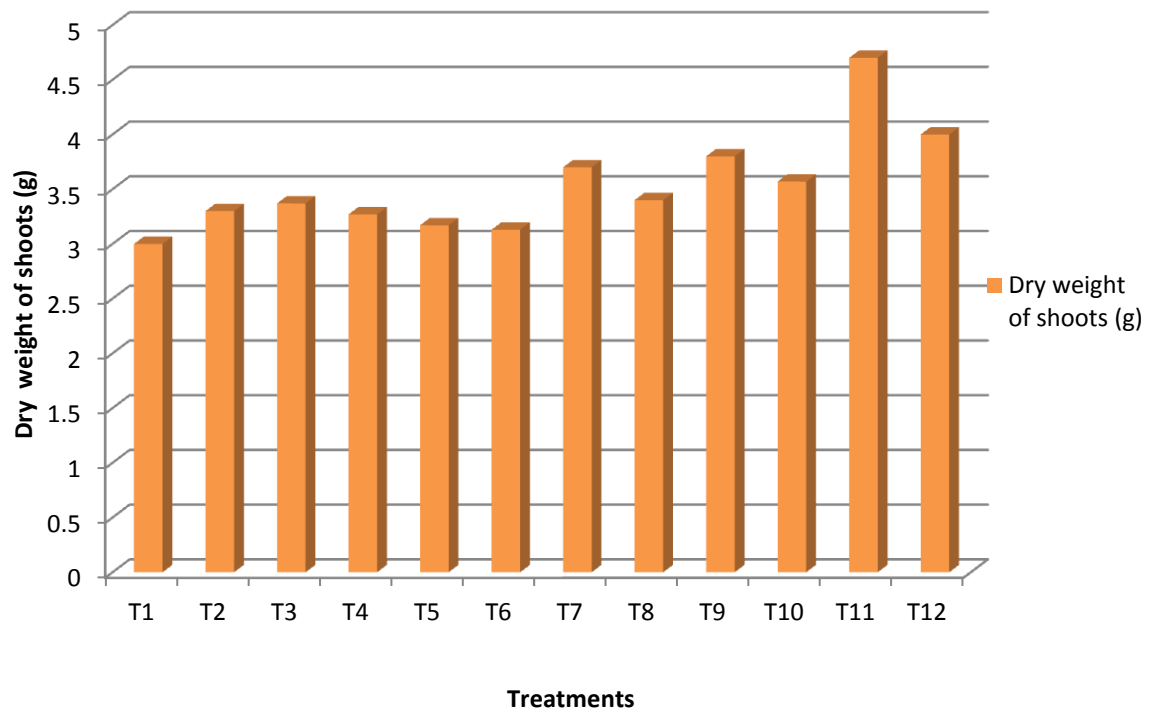
It can be observed from Table 4.4 and Fig. 4.4 that the effect of micronutrients on dry weight of shoots (g) was statistically significant during stages of observation at 45 DAP.

At 45 DAP the maximum dry weight of shoots (4.70 g) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄ which recorded values of 4.00g, 3.80g, 3.70g, 3.57g and 3.40 g respectively. The minimum dry weight of shoots (3.00g) at this stage was recorded by T₁ (control).

Table 4.4 Dry weight of shoots (g) at 45 DAP

Treatment	Dry weight of shoots(g)
(T ₁)	3.00
(T ₂)	3.30
(T ₃)	3.37
(T ₄)	3.27
(T ₅)	3.17
(T ₆)	3.13
(T ₇)	3.70
(T ₈)	3.40
(T ₉)	3.80
(T ₁₀)	3.57
(T ₁₁)	4.70
(T ₁₂)	4.00
S.Em.	0.22
CD(5%)	0.63

Fig. 4.4 Effect of micronutrient sprays on dry weight of shoots 45 DAP



4.2. Flowering parameters

4.2.1. Days taken for first flower appearance

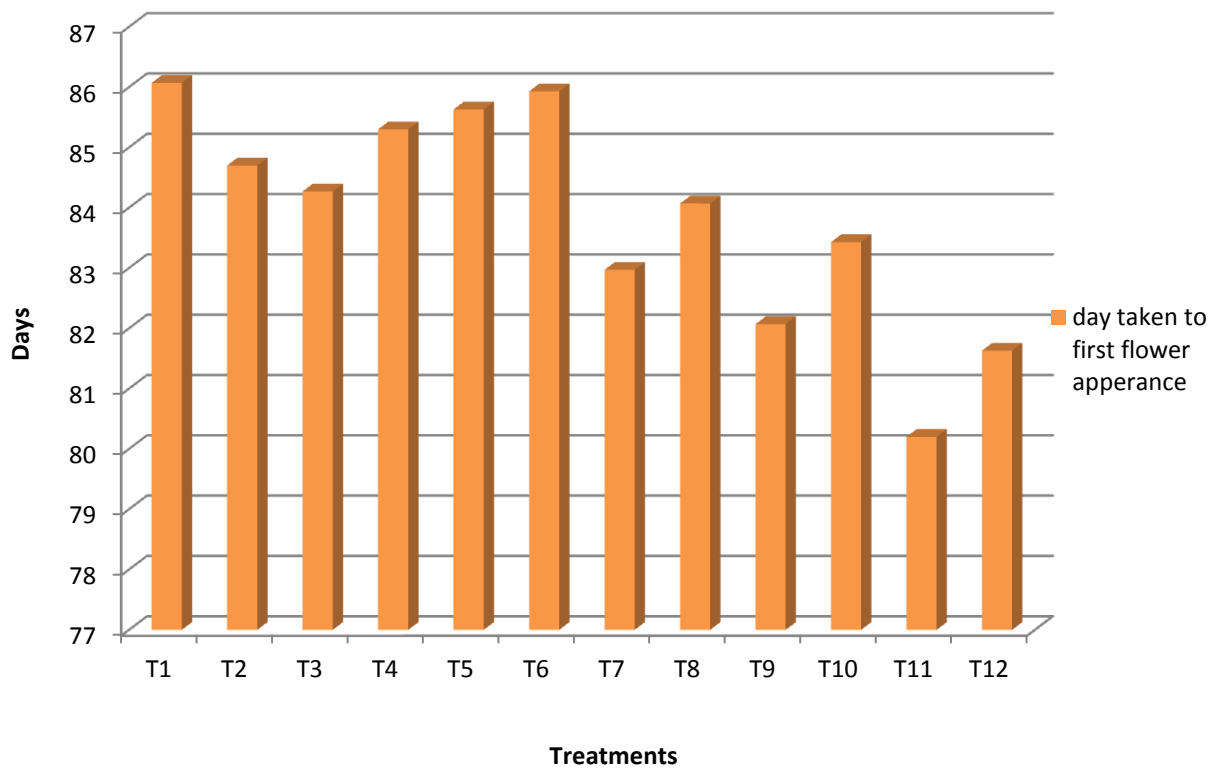
It can be observed from Table 4.5 and Fig. 4.5 that the effect of micronutrients on number of days taken for first flower appearance was statistically significant.

The earliest flower appearance (80.20days) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75% FeSO₄) which recorded values of 81.63 days, 82.07 days, 82.97 days, 83.43days and 84.07 days respectively. However, these treatments were statistically at par with one another. The most delayed flower appearance (86.07 days) was recorded by T₁ (control).

Table 4.5 Number of days taken for first flower appearance

Treatment	Number of days taken for first flower appearance
(T ₁)	86.07
(T ₂)	84.70
(T ₃)	84.27
(T ₄)	85.30
(T ₅)	85.63
(T ₆)	85.93
(T ₇)	82.97
(T ₈)	84.07
(T ₉)	82.07
(T ₁₀)	83.43
(T ₁₁)	80.20
(T ₁₂)	81.63
S.Em.	0.55
CD(5%)	1.60

Fig. 4.5 Effect of micronutrient sprays on days taken to first flower appearance



4.2.2 Flower diameter (cm)

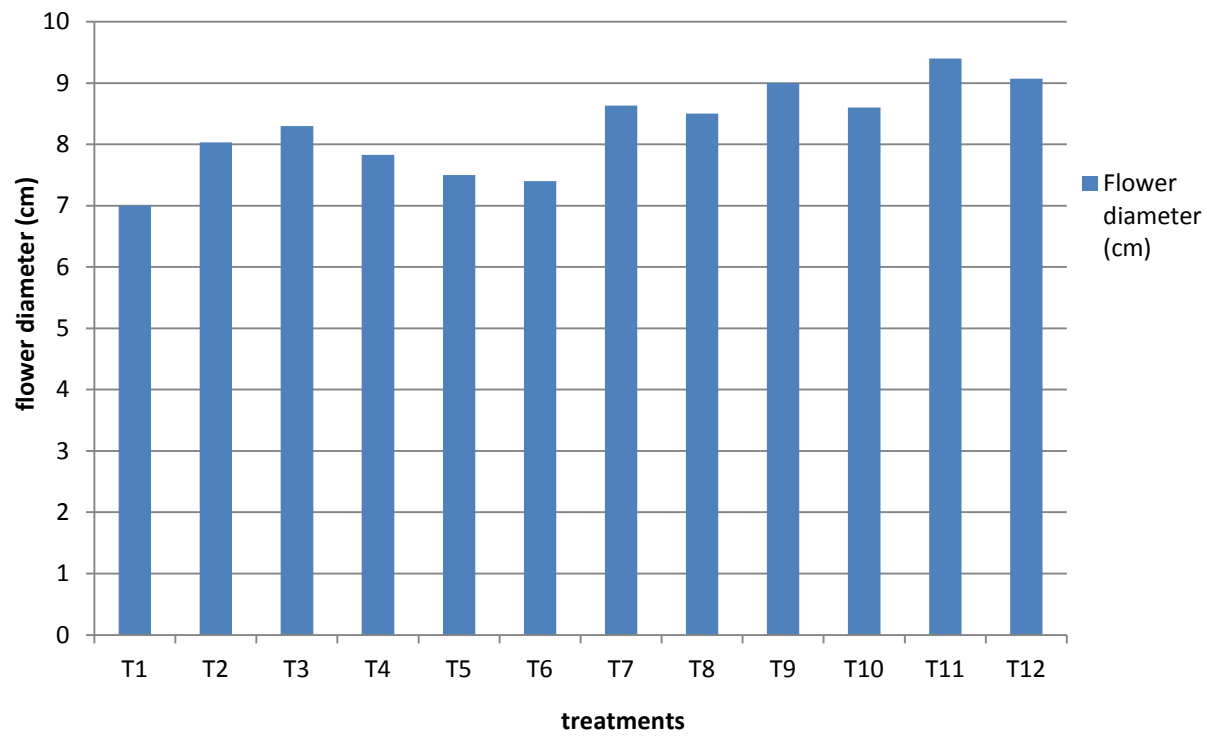
It can be observed from Table 4.6 and Fig. 4.6 that the effect of micronutrients on flower diameter (cm) was statistically significant.

The maximum flower diameter (9.40 cm) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄) which recorded values of 9.07cm, 9 cm, 8.63 cm, 8.60 cm, and 8.50 cm respectively. The minimum flower diameter (7 cm) was recorded by T₁ (control).

Table 4.6 Flower diameter (cm)

Treatment	Flower diameter (cm)
(T ₁)	7.00
(T ₂)	8.03
(T ₃)	8.30
(T ₄)	7.83
(T ₅)	7.50
(T ₆)	7.40
(T ₇)	8.63
(T ₈)	8.50
(T ₉)	9.00
(T ₁₀)	8.60
(T ₁₁)	9.40
(T ₁₂)	9.07
S.Em.	0.22
CD(5%)	0.63

Fig. 4.6 Effect of micronutrient sprays on flower diameter (cm)



4.2.3. Flower stalk length (cm)

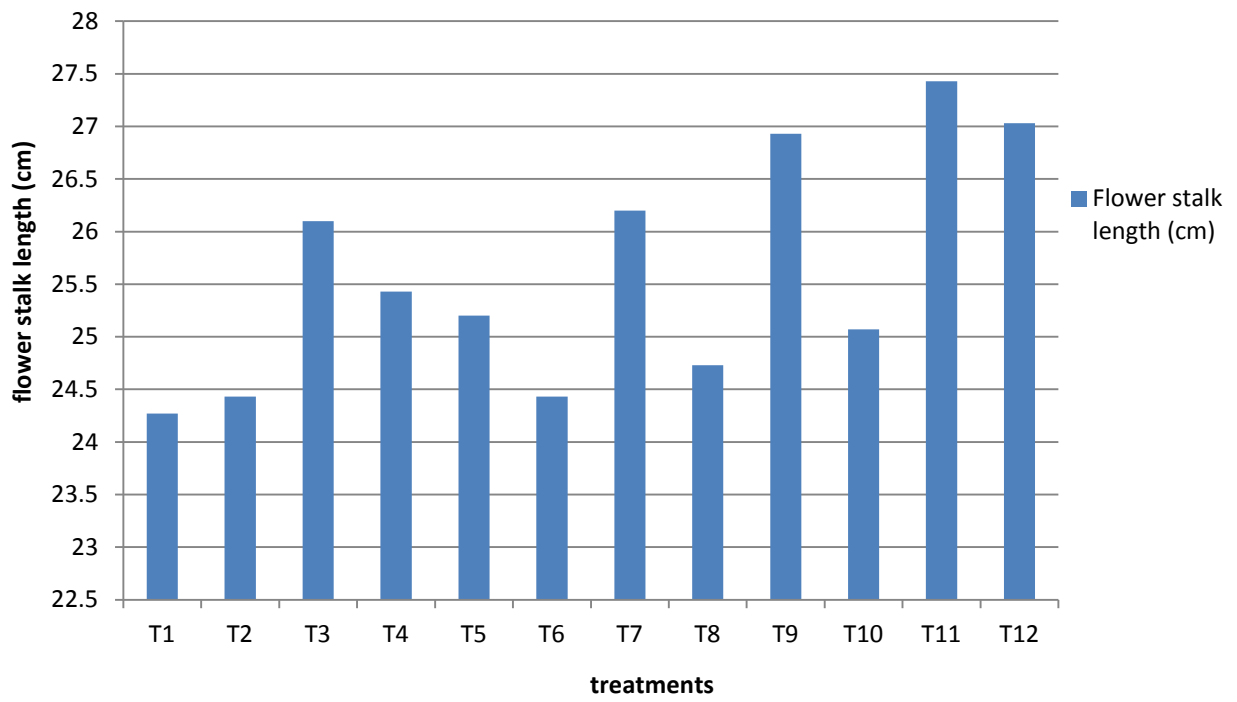
It can be observed from Table 4.7 and Fig. 4.7 that the effect of micronutrients on flower stalk length (cm) was statistically significant.

The maximum flower stalk length (27.43 cm) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75% FeSO₄) which recorded values of 27.03 cm, 26.93 cm, 26.20 cm, 25.07 cm and 24.73 cm respectively. The minimum flower stalk length (24.27cm) was recorded by T₁ (control).

Table 4.7 Flower stalk length (cm)

Treatment	Flower stalk length (cm)
(T ₁)	24.27
(T ₂)	24.43
(T ₃)	26.10
(T ₄)	25.43
(T ₅)	25.20
(T ₆)	24.43
(T ₇)	26.20
(T ₈)	24.73
(T ₉)	26.93
(T ₁₀)	25.07
(T ₁₁)	27.43
(T ₁₂)	27.03
S.Em.	0.22
CD(5%)	0.63

Fig. 4.7 Effect of micronutrient sprays on flower stalk length (cm)



4.2.4. Weight of individual flower (g)

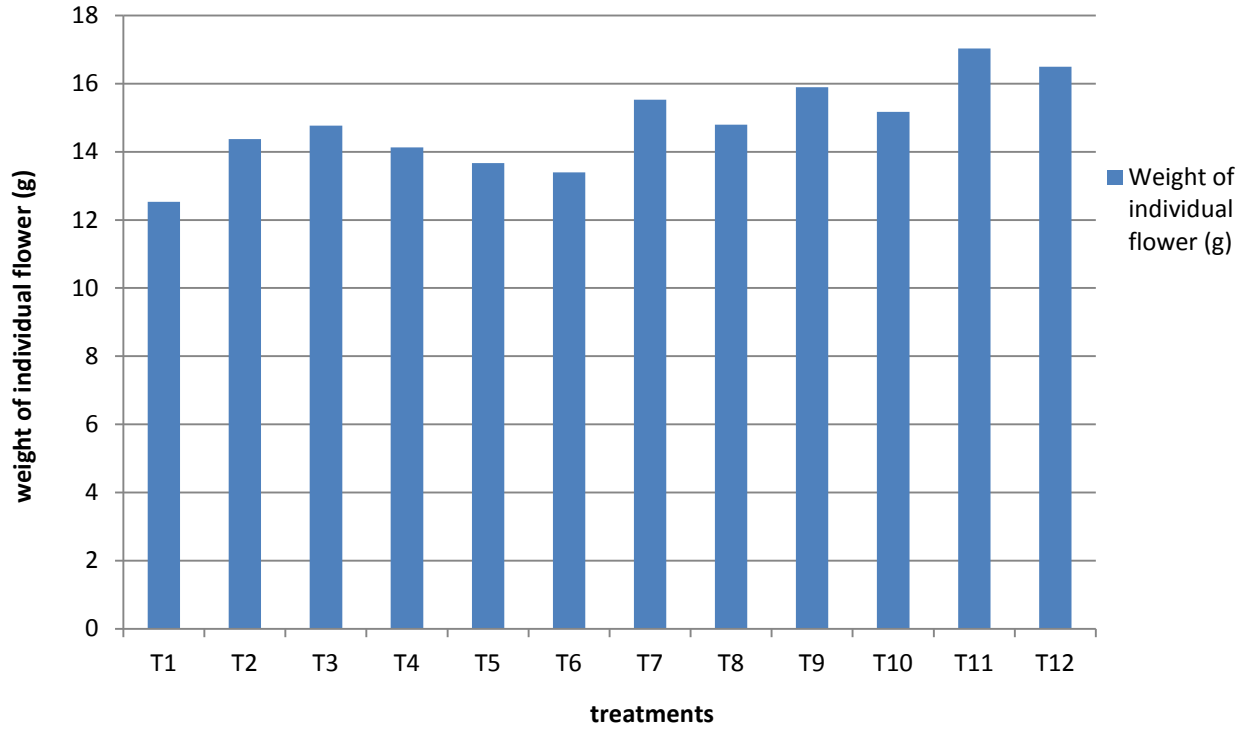
It can be observed from Table 4.8 and Fig. 4.8 that the effect of micronutrients on weight of individual flowers was statistically significant.

The maximum flower weight (17.03 g) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄) which recorded values of 16.50 g, 15.90 g, 15.53 g, 15.17 g and 14.80 g respectively. The minimum individual flower weight (12.53 g) was recorded by T₁ (control).

Table 4.8 Weight of individual flowers (g)

Treatment	Weight of individual flowers (g)
(T ₁)	12.53
(T ₂)	14.37
(T ₃)	14.77
(T ₄)	14.13
(T ₅)	13.67
(T ₆)	13.40
(T ₇)	15.53
(T ₈)	14.80
(T ₉)	15.90
(T ₁₀)	15.17
(T ₁₁)	17.03
(T ₁₂)	16.50
S.Em.	0.20
CD(5%)	0.58

Fig. 4.8 Effect of micronutrient sprays on weight of individual flowers (g)



4.2.5 Vase life of flowers (days)

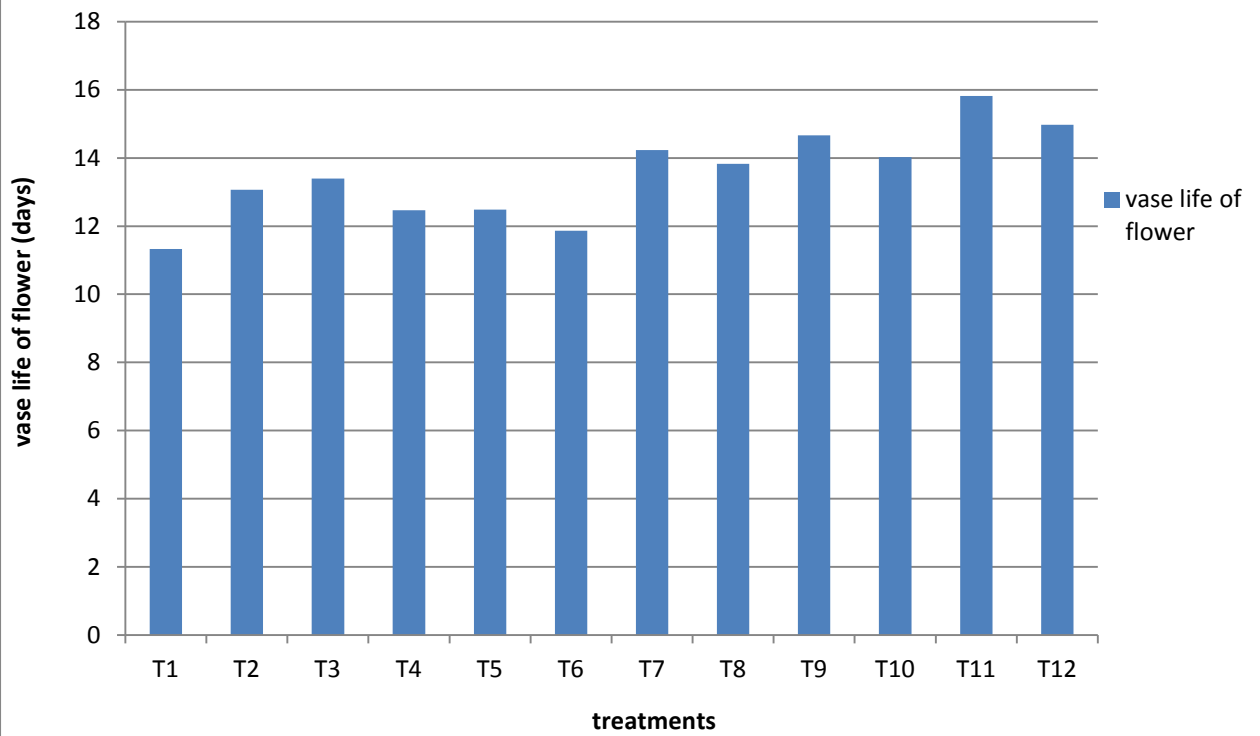
It can be observed from Table 4.2.5 and Fig. 4.2.5 that the effect of micronutrient sprays on vase life of flowers (days) was statistically significant.

The longest vase life of flower (15.82 days) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄+0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄+0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75% FeSO₄) which recorded a value of 14.97, 14.66, 14.23, 14.03 and 13.83 days. However, these treatments were at par with one another. The shortest vase life (11.33 days) was recorded by T₁ (control).

Table 4.9 Vase life of flowers (days)

Treatment	Vase life of flowers (days)
(T ₁)	11.33
(T ₂)	13.07
(T ₃)	13.40
(T ₄)	12.47
(T ₅)	12.48
(T ₆)	11.86
(T ₇)	14.23
(T ₈)	13.83
(T ₉)	14.66
(T ₁₀)	14.03
(T ₁₁)	15.82
(T ₁₂)	14.97
S.Em.	0.29
CD(5%)	0.86

Fig. 4.9 Effect of micronutrient sprays on vase life of flower (days)



4.3. Biochemical parameters.

4.3.1 Chlorophyll content in leaves (SPAD value):

It can be observed from Table 4.10 and Fig. 4.10 that the effect of micronutrients on chlorophyll content in leaves (SPAD value) was statistically significant during the stages of observation (before and after flowering).

Before flowering the maximum chlorophyll content in leaves (67.43) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄), which recorded values of 66.00, 65.10, 64.50, 64.13 and 63.67 respectively. The minimum chlorophyll content 59.60 at this stage was recorded by T₁ (control).

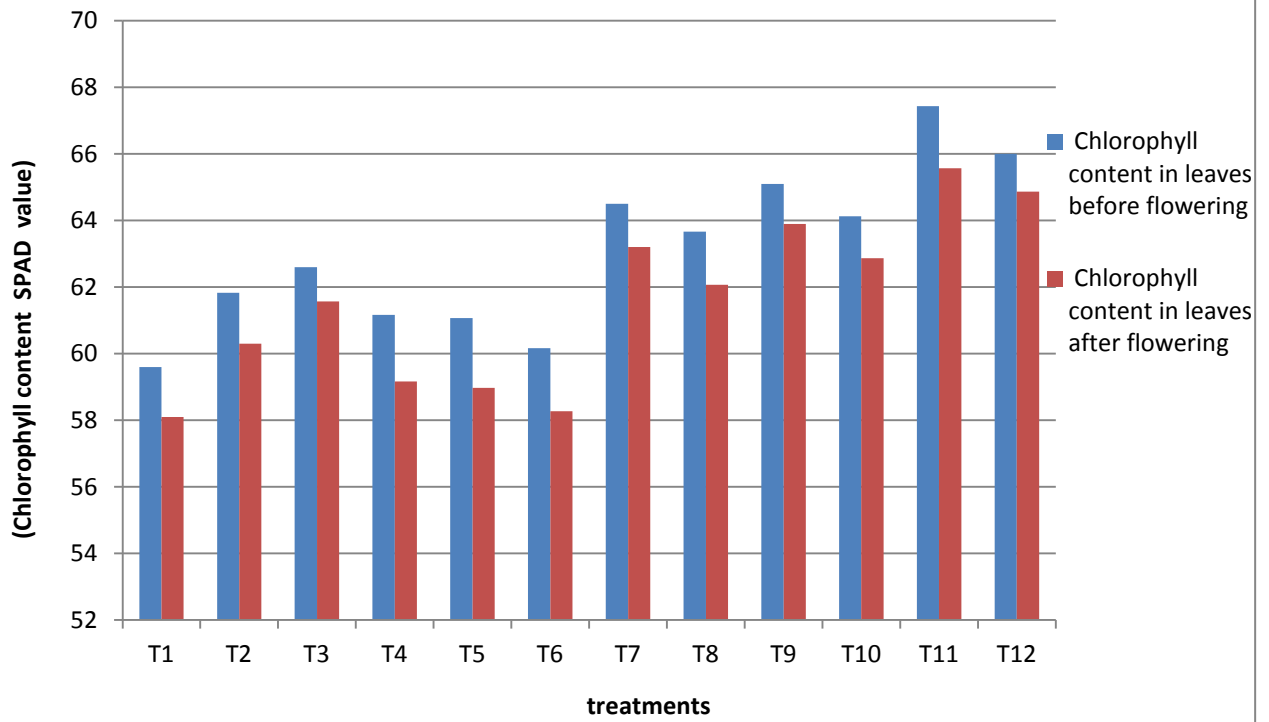
A similar trend was observed after flowering maximum. The chlorophyll content in leaves (65.57) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄), which recorded values of 64.87, 63.90, 63.20, 62.87 and 62.07 respectively. The minimum chlorophyll content 58.10 at this stage was recorded by T₁ (control).

Table 4.3.1 Chlorophyll content in leaves (SPAD value):

Treatment	Chlorophyll content in leaves (SPAD value) before flowering	Chlorophyll content in leaves (SPAD value) after flowering
(T ₁)	59.60	58.10
(T ₂)	61.83	60.30
(T ₃)	62.60	61.57
(T ₄)	61.17	59.17
(T ₅)	61.07	58.97
(T ₆)	60.17	58.27
(T ₇)	64.50	63.20
(T ₈)	63.67	62.07
(T ₉)	65.10	63.90
(T ₁₀)	64.13	62.87
(T ₁₁)	67.43	65.57

(T ₁₂)	66.00	64.87
S.Em.	0.55	1.40
CD(5%)	1.61	4.08

Fig. 4.10 Effect of micronutrient sprays on chlorophyll content in leaves (SPAD value)



5.3.2 Anthocyanin content in petals (mg/100g)

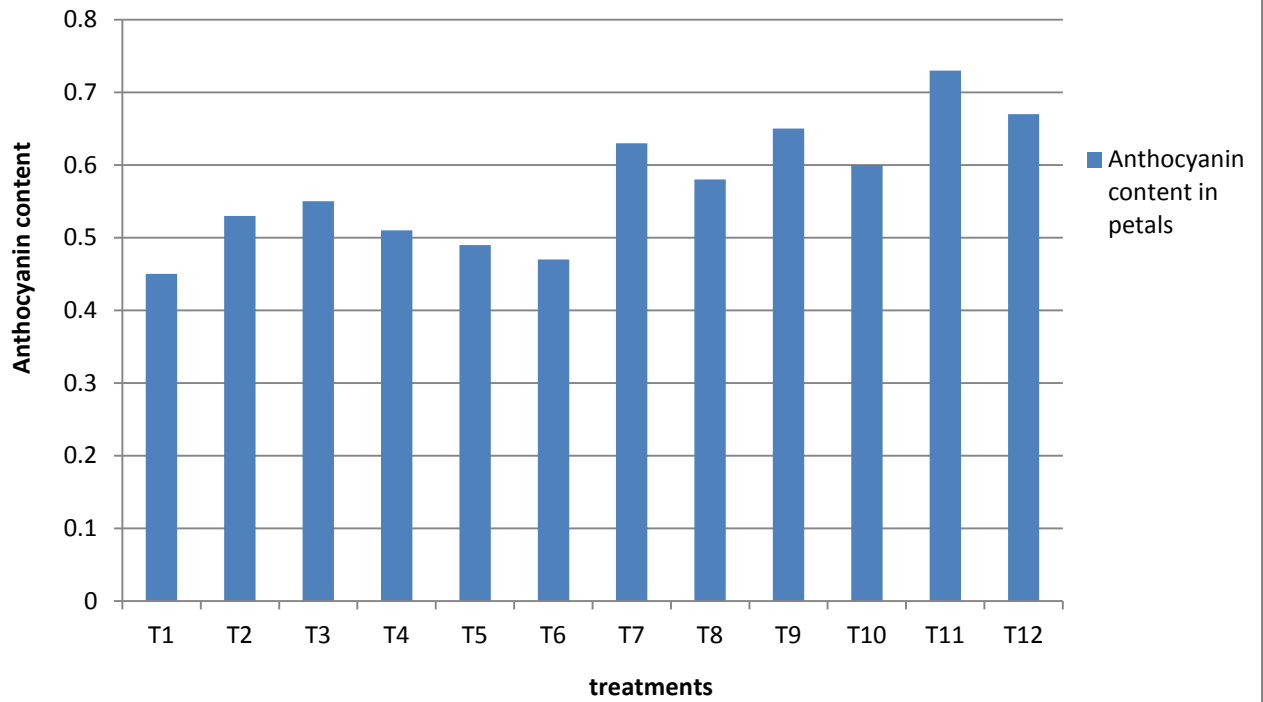
It can be observed from Table 4.11 and Fig. 4.11 that the effect of bio-fertilizers on anthocyanin content in petals (mg/100g) was statistically significant.

The highest anthocyanin content in petals (0.73mg/100g) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄), T₇ (0.50% ZnSO₄+ 0.50% FeSO₄), T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) and T₈ (0.50% ZnSO₄+ 0.75%) FeSO₄) which recorded a value of 0.67mg, 0.65mg,0.63mg,0.60mg and 0.58mg. The lowest anthocyanin content in petals (0.45mg/100g) was recorded by T₁ (control).

Table 5.11 Anthocyanin content in petals (mg/100g)

Treatment	Anthocyanin content in petals (mg/100g)
(T ₁)	0.45
(T ₂)	0.53
(T ₃)	0.55
(T ₄)	0.51
(T ₅)	0.49
(T ₆)	0.47
(T ₇)	0.63
(T ₈)	0.58
(T ₉)	0.65
(T ₁₀)	0.60
(T ₁₁)	0.73
(T ₁₂)	0.67
S.Em.	0.01
CD(5%)	0.04

Fig. 4.11 Effect of micronutrient sprays on anthocyanin content in petals (mg/100g)



4.3.3 Leaf nutrient content (ppm)

It can be observed from Table 4.12 and Fig. 4.12 that the effect of micronutrients on leaf nutrient content (ppm) was statistically significant.

The highest zinc content in leaf (11.55ppm) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax) and T₁₀ (0.75% ZnSO₄+ 0.75% FeSO₄) which recorded values of 11.40ppm and 10.79ppm respectively. The lowest Zinc content in leaf (8.30ppm) was recorded by T₁ control.

The highest boron content in leaf (27.30ppm) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax) and T₆ (0.2% Borax) which recorded values of 26.93ppm and 25.60ppm respectively. The lowest boron content in leaf (18.90ppm) was recorded by T₁ control.

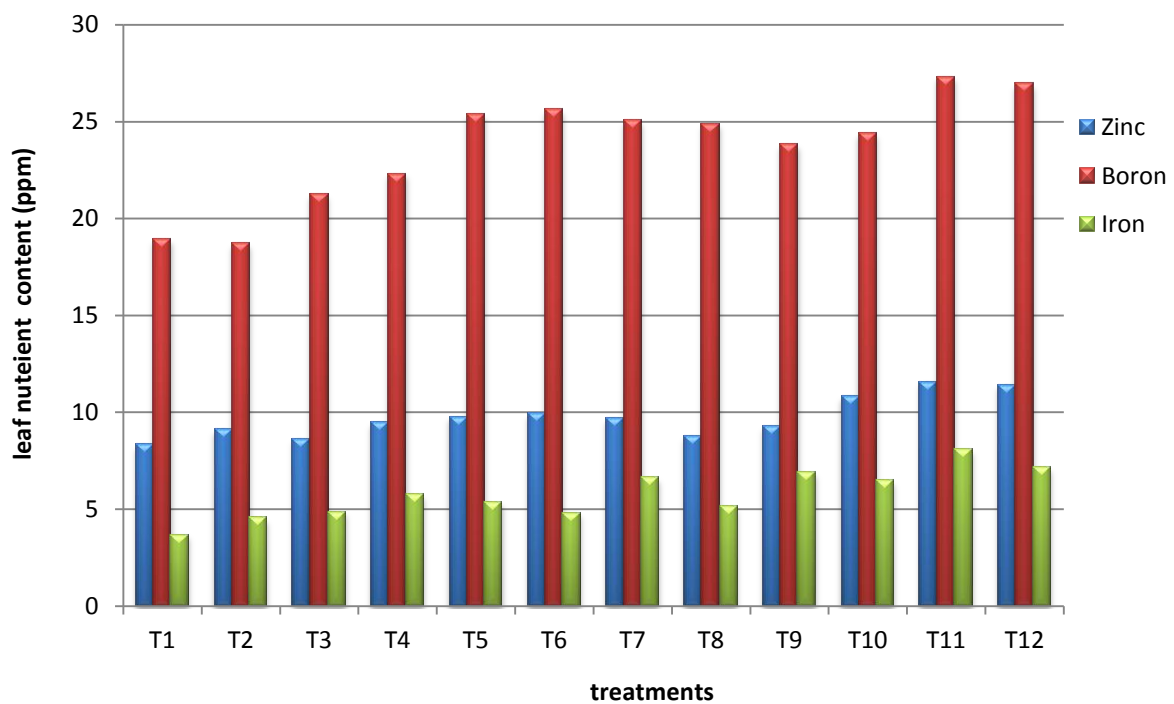
The highest iron content in leaf (8.07ppm) was recorded by T₁₁ (0.75% ZnSO₄+ 0.50% FeSO₄ +0.2% Borax) followed by T₁₂ (0.50% ZnSO₄+ 0.75% FeSO₄ +0.2% Borax) and T₉ (0.75% ZnSO₄+0.50% FeSO₄) which recorded values of 7.15ppm and 6.87ppm respectively. The lowest Zinc content in leaf (3.66ppm) was recorded by T₁ control.

Table 4.12 Leaf nutrient content (ppm)

Treatment	Zinc	Boron	Iron
(T ₁)	8.30	18.90	3.66
(T ₂)	9.13	18.73	4.53
(T ₃)	8.63	21.23	4.85
(T ₄)	9.47	22.30	5.72
(T ₅)	9.75	25.37	5.35
(T ₆)	9.93	25.60	4.81
(T ₇)	9.68	25.07	6.64
(T ₈)	8.77	24.87	5.13
(T ₉)	9.25	23.83	6.87

(T ₁₀)	10.79	24.40	6.48
(T ₁₁)	11.55	27.30	8.07
(T ₁₂)	11.40	26.93	7.15
S.Em.	0.62	0.67	0.32
CD(5%)	1.80	1.95	0.93

Fig. 4.12 Effect of micronutrient sprays on leaf nutrient content (ppm)



Chapter- V

DISCUSSION

In this chapter an attempt has been made to evaluate the possible reasons of the variability obtained due to treatment differences in the present investigation entitled “**Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh**” The findings described in the preceding chapter have been critically discussed here in detail.

5.1: Growth characteristics

5.1.1: Plant height (cm)

In the present study the maximum plant height (cm) during the different stages (30, 45 and 60 days after planting) was recorded with the application of treatment T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum plant height (cm) was recorded with T₁ (control). FeSO₄ and ZnSO₄ play major role in synthesis of tryptophan, which is precursor of auxin (IAA) and it, is an essential for nitrogen metabolism which stimulates growth in the plants. Similar findings have been reported by Kakade *et al.* (2009) in China aster, Reddy and Chaturvedi (2009) in gladiolus and Dashora *et al.* (2004) in marigold.

5.1.2: Number of leaves per plant

In the present study the maximum number of leaves per plant was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum number of leaves per plant was recorded with T₁ (control). Increased in number of leaves per plant may be due to increased cell division in plants. Similar findings were reported by Khan (2000), Kumar and Arora (2000) in gladiolus, Halder *et al.* (2007), Ganga *et al.* (2009), Khosa *et al.* (2011) and Lahijie (2012) in gladiolus.

5.1.3. Fresh weight (g) of shoots 45 DAP

In the present study the maximum fresh weight of shoots (g) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum fresh weight of shoots (g) was recorded with T₁ (control). ZnSO₄ plays a vital role in production of vegetative growth and ultimately encourages the biomass of plant which results in increased fresh weight of plant.

These results are in agreement with findings of Mona *et al.* (2002) in marigold and Siddiqui *et al.* (2009) in sunflower.

1.4 Dry weight of shoots (g) at 45 DAP

In the present study the maximum dry weight of shoots (g) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum dry weight of shoots (g) was recorded with T₁ (control). The increase in dry weight with zinc dose could be attributed to availability of nutrient for photosynthesis and dry matter accumulation along with higher availability and uptake of zinc by the plants which ultimately enhanced the dry weight (Abdi *et al.*). Similar results were also reported by Samia and Mahmoud (18) in Tritonia and Yadegari and Shakerian (22) in marigold.

5.2: Flowering parameters

5.2.1 Days taken for first flower appearance

In the present study the earliest first flower appearance was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the most delayed last flower appearance was recorded with T₁ (control). The early flower bud opening in borax spray may be due to its role in translocation of sugars, starches, phosphorous etc, which might have been utilized for better development of early flower bud opening (Das, 1996).

5.2.2 Flower diameter (cm)

In the present study the maximum flower diameter (cm) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum flower diameter (cm) was recorded with T₁ (control). The increment in flower diameter may be due to enhanced cell division and cell enlargement. This is in agreement with the finding of. Khan (2000) in Dahlia, Muthumanickam *et al.* (2009) in gerbera.

5.2.3 Flower stalk length (cm)

In the present study the maximum flower stalk length (cm) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum flower stalk length (cm) was recorded with T₁ (control). The increment in stalk length could be due to enhanced cell division and cell enlargement. This is in agreement with the finding of Khan (2000) in Dahlia, Muthumanickam *et al.* (2009) in

gerbera and Bhattacharjee and Singh (1992) in floribunda roses in rose reported similar findings.

5.2.4. Weight of individual flower (g)

In the present study the maximum weight of individual flower (g) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum weight of individual flower (g) was recorded with T₁ (control). These may be due to the association of zinc in regulating semi permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which promotes cell size (Agarwal and Sharma, 1978) which in turn increases the flower size and weight of the flowers. Similar results were reported by Nag and Biswas (2003) and Kumar *et al.* (2003) in tuberose.

5.2.5. Vase life of flowers (days)

In the present study the maximum vase life of flower (days) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum vase life of flower was recorded with T₁ (control). ZnSO₄ and MnSO₄ recorded maximum water uptake while the control recorded minimum water uptake. Comparatively higher water uptake of water in ZnSO₄ treatment may be due to higher tolerance to bacteria and thus slow development of vascular occlusion (Van Doorn *et al.*, 1989).

5.3 Bio- chemical parameters

5.3.1 Chlorophyll content in leaves (SPAD value)

In the present study the maximum chlorophyll content in leaves (SPAD value) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum chlorophyll content in leaves (SPAD value) was recorded with T₁ (control). Micronutrients activate several enzymes (catalase, peroxidase, alcohol, dehydrogenase, carbonic dehydrogenase and tryptophane synthetase etc) and involve themselves in chlorophyll syntheses and various physiological activities. This may be due to the indirect role of iron in chlorophyll bio-synthesis. The above findings are in close agreement with finding of Balakrishnan *et al* (2007) in marigold.

Presence of iron would have enhanced the functioning of photosystem, which ultimately increased the chlorophyll in leaves and xanthophyll in flowers. Similar findings have been reported by Sha and Karuppaiah (2005) in Chilli.

5.3.2. Pigment in petals (mg/100g)

In the present study the maximum pigment content in petals was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum pigment content in petals was recorded with T₁ (control). Increase in pigment content due to the micronutrients (Fe and Zn) activate several enzyme (catalase, peroxidase, alchohal dehydrogenase, carbonic dehydrogenase and tryptophan synthatase etc) and involve themselves in chlorophyll synthesis and various physiological activities (Kumar and Haripriya , 2010). Iron plays a very important role in pigments synthesis (Naik *et al.*, 2008).

5.3.3. Leaf nutrient content (ppm)

In the present study the maximum leaf nutrient content (ppm) was recorded with the application of T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax), while the minimum leaf nutrient content (ppm) was recorded with T₁ (control). This is an important consideration since iron is associated with chlorophyll formation and is an important constituent of several plant compounds and enzymes as they are involved in many redox reactions (Pratap *et al*, 2005). Micronutrients (Fe and Zn) are co-factor for several enzymes (Cytochromes, Perodoxin, Alcohol dehydrogenase, Arginase, phosphotransferase, carbonic anhydrase and carboxy peptidase etc) and involve themselves in chlorophyll synthesis and various physiological activities, These result are in accordance with the finding of Pratap *et al.*, (2005).

CHAPTER - VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK.

6.1 Summary

The present investigation entitled “**Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh**” was conducted during the period from 19th July 2016 to 12th December 2016 at the Department of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.).

The experiment was laid out in Completely Randomized Design with three replications. Chrysanthemum cv. Hybrid-1 was used for the experiment. Five different doses micronutrient treatments viz. of ZnSO₄ 0.50%, 0.75%, FeSO₄ 0.50%, 0.75% and Borax 0.2% were applied. The observations on different growth, flowering, and biochemical parameters were recorded and the results obtained are summarized below.

6.1.1: Growth parameters

The plant height (cm) at 30,45 & 60 days after planting, number of leaves per plant at 45 days after planting, fresh weight of shoots (g) at 45 days after planting and dry weight of shoots (g) at 45 days after planting were significantly affected by various treatments of micronutrients. Maximum plant height (cm) at 30,45 & 60 days after planting, number of leaves per plant at 45 days after planting, fresh weight of shoots (g) at 45 days after planting and dry weight of shoots (g) at 45 days after planting were recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄)) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) The minimum plant height (cm) at 30,45 & 60 days after planting, number of leaves per plant at 45 days after planting, fresh weight of shoots (g) at 45 days after planting and dry weight of shoots (g) at 45 days after planting was recorded by T₁ (control).

6.1.2: Flowering parameters

The number of days taken for first flower appearance was influenced significantly by micronutrients. The earliest first flower appearance was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) The most delayed flower appearance was recorded by T₁ (control).

The flower diameter (cm), flower stalk length (cm), weight of individual flower (g) and vase life of flower (days) was influenced significantly by micronutrients. The maximum flower diameter (cm), flower stalk length (cm), weight of individual flower (g) and vase life of flower (days) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) respectively. The minimum flower diameter (cm), flower stalk length (cm), weight of individual flower (g) and vase life of flower (days) was recorded by T₁ (control).

6.1.3: Biochemical parameters

The chlorophyll content in leaves (SPAD value) was influenced significantly by micronutrient. The highest chlorophyll content in leaves (SPAD value) was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) respectively. The lowest chlorophyll content in leaves was recorded by T₁ (control).

The anthocyanin content in petals was influenced significantly by micronutrients. The highest anthocyanin content in petals was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax), T₉ (0.75% ZnSO₄+0.50% FeSO₄) and T₇ (0.50% ZnSO₄+0.50% FeSO₄) respectively. The lowest anthocyanin content in petals was recorded by T₁ (control).

The leaf nutrient content (ppm) was influenced significantly by micronutrients. The highest Zinc content in leaf before and after flowering was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax) and T₁₀ (0.75% ZnSO₄+0.75% FeSO₄)

respectively. The lowest Zinc content in leaf (SPAD value) was recorded by T₁ (control).

The leaf nutrient content (ppm) was influenced significantly by micronutrients. The highest Boron content in leaf was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax) and T₆ (0.2% Borax) respectively. The lowest Boron content in leaf was recorded by T₁ (control).

The leaf nutrient content (ppm) was influenced significantly by micronutrients. The highest Iron content in leaf was recorded by T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) followed by T₁₂ ((0.50% ZnSO₄+0.75% FeSO₄ +0.2% Borax) and T₉ (0.75% ZnSO₄+0.50% FeSO₄) respectively. The lowest Iron content in leaf was recorded by T₁ (control).

6.2 Conclusions

- The different micronutrient treatments had significant influence on the vegetative growth, flowering and biochemical parameters of chrysanthemum in the present study.
- Among the micronutrient treatments T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) recorded the maximum values of plant height (cm), number of leaves per plant, fresh weight of shoots(g) and dry weight of shoots(g).
- T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) recorded the earliest flower appearance, maximum flower diameter (cm), maximum flower stalk length, maximum weight of individual flower and longest vase life of flower (days).
- T₁₁ (0.75% ZnSO₄+0.50% FeSO₄ +0.2% Borax) was found superior in biochemical parameters as it recorded the maximum chlorophyll content, maximum pigment in petals and highest leaf nutrient content.

6.3 Suggestion for future work

- Following future line of work is suggested for obtaining improved growth, flowering and biochemical of chrysanthemum for benefit to growers.
- Since it was the first year of the trial, it is suggested that, findings of the present study must be tested over years and locations for confirmation.
- The study may be repeated with more number of chrysanthemum cultivars suitable for the Malwa region of Madhya Pradesh.

- More number of micronutrients with different concentrations may be tested for improving of growth and yield of chrysanthemum flowers.
- Effect of micronutrients on growth and flowering of other commercial flowers suitable for the Malwa region of Madhya Pradesh may be studied.

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APPENDICES

Appendix- I: Analysis of variance for Plant height (cm).

Source of variation	D.F.	Mean sum of squares		
		Plant height (cm)		
		30 DAP	45 DAP	60 DAP
Treatment	11	9.04	9.82	8.16
Error	24	2.60	2.38	1.95
Total	35			

Appendix- II: Analysis of variance for fresh weight of shoots (g) and dry weight of shoots (g).

Source of variation	D.F.	Mean sum of squares	
		Fresh weight of shoots(g)	Dry weight of shoots(g)
		45 DAP	45 DAP
Treatment	11	10.36	0.66
Error	24	1.82	0.14
Total	35		

Appendix- III: Analysis of variance number of leaves per plant 45 (days) and days taken for first flower appearance.

Source of variation	D.F.	Mean sum of squares	
		number of leaves per plant 45 days	Days taken for first flower appearance
Treatment	11	9.15	10.32
Error	24	1.26	0.90
Total	35		

Appendix- IV: Analysis of variance for flower diameter (cm) and flower stalk length (cm)

Source of variation	D.F.	Mean sum of squares	
		Flower diameter (cm)	Flower stalk length(cm)
Treatment	11	1.62	3.69
Error	24	0.14	1.52
Total	35		

Appendix- V: Analysis of variance for weight of individual flower (g) and vase life of flowers (days)

Source of variation	D.F.	Mean sum of squares	
		Weight of individual flower(g)	Vase life of flower (days)
Treatment	11	5.12	5.32
Error	24	0.12	0.26
Total	35		

Appendix- VI: Analysis of variance for pigment content in petals and chlorophyll content in leaves.

Source of variation	D.F.	Mean sum of squares		
		Pigment content in petals	Chlorophyll content in leaves before flowering	Chlorophyll content in leaves after flowering
Treatment	11	0.02	17.75	20.17
Error	24	0.00	0.91	5.85
Total	35			

Appendix- VII: Analysis of variance for leaf nutrient content .

Source of variation	D.F.	Mean sum of squares		
		Leaf nutrient content		
		Zinc	Boron	Iron
Treatment	11	3.30	24.35	4.91
Error	24	1.14	1.33	0.30
Total	35			

VITA

The author of this thesis **Manish Kumar Verma** was born on 10 August 1992 at Village- Jhuranadi, Post- Shakha, Tah. Chhuikhadan, Dist. Rajnandgaon (C.G.). He passed High School Examination in the year 2008 from C.G.Board Raipur from R. N.T. H.S.School Khaira Narmada and Higher Secondary Examination in the year 2010 from C.G.Board, Raipur from Govt. Boys H.S.School. Chhuikhadan. With 55% and 56.67% marks respectively.

He joined College Of Agriculture A. Chowki Rajnandgaon C.G. in 2010-11 and completed B.Sc. (Agri.) in the year 2014 with 2st division securing an OGPA of 6.47 on 10 point scale.

After graduation, he joined M.Sc. (Horticulture) in College of Horticulture, Mandasaur with specialization in Floriculture and Landscape Architecture. He has completed the entire course requirement for the above said Master Degree in the year 2016-17 with an OGPA of 7.2 on a 10 point scale.

He was allotted an interesting research problem entitled **“Response of standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) to micronutrient sprays in the Malwa region of Madhya Pradesh”** of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

(Manish Kumar Verma)



