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Effect of micronutrients on yield of *Crossandra* (*Crossandra infundibuliformis* L.) cv. Delhi

Lenin A R[1], Rizwana Begum Z[2], Kalaiselvan S[3], Dhanasekaran D[4]
[1] Assistant Professor, Department of Horticulture, Annamalai University, Annamalai Nagar, Tamil Nadu, India
[2] Senior Research Fellow, Tamilnadu Horticulture Management Institute (TNHMI), Arul Nagar, Milk Colony, Madhavaram, Tamil Nadu, India
[3] Ph.D. Scholar, Department of Horticulture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Abstract
Crossandra is an important commercial loose flower crop which is a herbaceous perennial ever green, semi shrub, It is a species of flowering plant in the family Acanthaceae. The present investigation was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2019-2020 in Randomized Block Design with eleven treatments and three replications. Eleven treatment combinations were formed for foliar application of micronutrients *viz*., T_1 – RDF + 0.2% ZnSO4, T_2 – RDF + 0.2% FeSO4, T_3 – RDF + 0.2% MgSO4, T_4 – RDF + 0.2% ZnSO4 + 0.2% MgSO4, T_5 – RDF + 0.2% ZnSO4 + 0.2% FeSO4, T_6 – RDF + 0.5% ZnSO4, T_7 - RDF + 0.5% FeSO4, T_8 – RDF + 0.5% MgSO4, T_9 – RDF + 0.5% ZnSO4 + 0.5% MgSO4, T_{10} – RDF + 0.5% ZnSO4 + 0.5% FeSO4 and T_{11} - RDF + water spray (Control) were studied on different micronutrient. The effect of treatments was studied based on their biometric observations *viz*., days taken to first flowering, number of spikes per plant, spike length (cm), number of flowers per spike, hundred flower weight (g), length of individual flower (cm), flower yield per plant (g), flower yield per plot (g) and flower yield per hectare (q). Among the eleven treatments, T_{10} exhibited maximum value followed by T_5 for all characters except number of spikes per plant. In respect to number of spikes per plant, the maximum value was achieved by T_5 followed by T_{10}.

Keywords: micronutrients, Zn, Fe, Mg, yield, *Crossandra*

Introduction
Crossandra is an important commercial loose flower crop which is a herbaceous perennial ever green, semi shrub, It is a species of flowering plant in the family Acanthaceae, native to southern India and Sri Lanka. It is most often found in south Indian region Malenadu. It is an erect, grows upto a height of 1 m (3 ft 3 in) with glossy, wavy-margined leaves and fan-shaped flowers, which may appear at any time throughout the year. The flowers are unusually shaped with 3 to 5 asymmetrical petals. They grow from four-sided stalked spikes, and have a tube-like ¾ inch stalk.
Flower colours range from the common orange to salmon-orange or apricot, coral to red, yellow and even turquoise. The flowers have no perfume but stay fresh for several days on the bush. A well-tended specimen will bloom continuously for years. The tiny flowers are often strung together into strands, sometimes along with white jasmine flowers and therefore in great demand for making garlands which are offered to temple deities or used to embellish women's hair.
Crossandra is the popular flower grown in India due to availability of various varieties suitable for year round cultivation. Quality is one of the most important parameter in the flower industry which is mainly influenced by application of nutrients. Integrated supply of micro-nutrients with macro-nutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth in flowering crops. The amounts of micro-nutrients required for proper growth and flowering of *Crossandra*. Micro-nutrients such as boron (B), iron (Fe), zinc (Zn), copper (Cu), chloride (Cl), manganese (Mn), molybdenum (Mo) and nickel (Ni) are involved in various metabolic processes (Zende, 2008) [8]. Hence, the present investigation was carried out to study the effect of micronutrients on yield of *Crossandra* cv. Delhi.

Materials and Methods
The present investigation on the "Effect of micronutrients on growth of *Crossandra* (*Crossandra infundibuliformis* L.)" was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2019-2020 in Randomized Block Design with eleven treatments and three replications. The plants were raised at spacing of 60 x 40 cm. The plants were sprayed with foliar application of eleven treatment combinations of different micronutrients. Twelve plants of each entry in each replication were randomly selected for recording the observations on days taken to first flowering, number of spikes per plant, spike length (cm), number of flowers per spike, hundred flower weight (g), length of individual flower (cm), flower yield per plant (g), flower yield per plot (g), flower yield per hectare (q).

Preparation of foliar spray solutions
The foliar stock solutions were prepared as per the treatment schedule. Where, Zinc Sulphate, Ferrous sulphate, and Magnesium sulphate are water soluble in nature. 2000mg (2g) of ZnSO4, FeSO4 and MgSO4 was dissolved in 1 liter of water to get 0.2% (2000ppm) Zinc Sulphate, Ferrous sulphate, and Magnesium sulphate stock solution. 5g of ZnSO4, FeSO4 and MgSO4 was dissolved in 1 liter of water to get 0.5% (5000 ppm) Zinc sulphate, Ferrous sulphate, and

Magnesium sulphate stock solution. The required foliar spray stock solutions were prepared as spray solutions in water as per the treatment requirements. From the stock solution, the required spray solutions are prepared through serial dilution. The spray solutions were given during the month of November 2019, January, and March, 2020

Table 1: Treatment details

Treatments	Treatments details
T_1	RDF + 0.2% ZnSO4 of foliar spray on 45th, 90th, and 125th DAP
T_2	RDF + 0.2% FeSO4 of foliar spray on 45th, 90th, and 125th DAP
T_3	RDF + 0.2% MgSO4 of foliar spray on 45th, 90th, and 125th DAP
T_4	RDF + 0.2% ZnSO4 + 0.2% MgSO4 of foliar spray on 45th, 90th, and 125th DAP
T_5	RDF + 0.2% ZnSO4 + 0.2% FeSO4 of foliar spray on 45th, 90th, and 125th DAP
T_6	RDF + 0.5% ZnSO4 of foliar spray on 45th, 90th, and 125th DAP
T_7	RDF + 0.5% FeSO4 of foliar spray on 45th, 90th, and 125th DAP
T_8	RDF + 0.5% MgSO4 of foliar spray on 45th, 90th, and 125th DAP
T_9	RDF + 0.5% ZnSO4 + 0.5% MgSO4 of foliar spray on 45th, 90th, and 125th DAP
T_{10}	RDF + 0.5% ZnSO4 + 0.5% FeSO4 of foliar spray on 45th, 90th, and 125th DAP
T_{11}	RDF + water spray (Control)

RDF-Recommended dose of fertilizer; DAP–days after planting.

Results

The results of the present investigation were revealed that foliar spray of zinc, iron and magnesium individually and in combination significantly influenced the plant yield on *Crossandra* cv. Delhi. The various treatments significantly influenced the days taken to first flower initiation (Table.2). Earliness in flowering 44.22 days was recorded in T10 followed by T5 in 45.82 days. The maximum days for first flower initiation taken in 65.25 days in T11.

Among the different treatments, the maximum number of flower per spike (Table.2) were observed in T10 with the values of 42.37. However, it was followed by T5 with 40.89 number of flowers per spike. The minimum number of flowers per spike 27.83 were observed in control (T11).

Among the various treatments significantly influenced the hundred flower weight (Table.2). The highest value of 12.45g was noticed in T10 followed by T5 which recorded the value of 40.89. The minimum number of flower per spike is 27.83 were recorded in control (T11). Among the different treatments, the maximum length of individual flower (Table.2) observed in T10 with the value of 5.60 cm. However, it was followed by T5 which recorded the value of 5.39 cm. The minimum length of flower 3.53 cm was observed in control (T11).

Among the different treatment the maximum length of spike (Table.3) was observed in T10 with the values of 6.03, 7.25, 9.75 and 11.02cm respectively on 60th, 90th, 120th,60 150th, and 180th days after planting.. However, it was followed by T5 which recorded the values of 5.78, 7.02, 9.49 and 10.78cm on 60th, 90th, 120th, 150th, and 180th days after planting respectively. The minimum length of spikes values of 3.74, 5.11, 7.63 and 8.89cm on 60th, 90th, 120th, 150th, and 180th days after planting (DAP) respectively were observed in control (T11).

All the treatments were found to differ significantly against the control for number of spikes per plant (Table.3). The treatment T5 recorded the highest values of 3.14, 5.25, 8.31, 12.23 and 16.42 on 60th, 90th, 120th, 150th, and 180th days after planting (DAP), followed by T10 with the values of 2.91, 4.14, 6.89, 10.07, and 14.91 on 60th, 90th, 120th, 150th, and 180th days after planting. The least values were recorded by control (T11) with the values of 1.56, 2.11, 4.33, 5.99 and 9.12 on 90th, 120th, 150th, and 180th days after planting respectively.

Various treatments significantly influenced the flower yield per plant (Table.4). Among them T10 was found to be recorded the maximum flower yield per plant (50.15g), followed by T5 which recorded the value of 48.43g per plant. The minimum flower yield per plant 33.01 g per plant was observed in control (T11).

Various treatments significantly influenced the flower yield per plot (Table.4). Among them, T10 was found to be recorded the maximum flower yield per plot 1245.28 g per plant followed by, T_5 which recorded the value of 1202.89 g per plot. The minimum flower yield per plant plot was 822.66g observed in control (T11) Flower yield per hectare.

Various treatments significantly influenced the flower yield per hectare (Table.4). Among them, T_{10} was found to be recorded the maximum flower yield per hectare (19.75 q), followed by T_5 which recorded the value of 19.05 q flower yield per hectare. The minimum flower yield per hectare (12.83q) was observed in control (T_{11}).

Table 2: Effect of micronutrients on days taken to first flower initiation, no. of flowers per spike, 100 flower weight and length of individual flower of *Crossandra* (*Crossandra infundibuliformis L.)*

Treatments	Days taken to first flower initiation	No. of flowers per Spike	100 flower weight (g)	Length of the individual flower (cm)
T_1	51.79	34.90	9.74	4.51
T_2	58.54	31.77	8.64	4.06
T_3	60.78	30.57	8.36	3.91
T_4	48.05	37.91	10.88	4.94
T_5	45.82	40.89	11.94	5.39
T_6	49.55	36.42	10.31	4.73
T_7	54.03	33.35	9.18	4.29
T_8	63.01	29.03	7.79	3.68
T_9	48.55	39.42	11.42	5.17
T_{10}	44.22	42.37	12.45	5.60
T_{11}	65.25	27.83	7.43	3.53
SE.d	1.16	0.68	0.039	0.08
CD=(P=0.05)	2.42	1.42	0.19	0.18

Table 3: Effect of micronutrients on spike length and no. of spike per plant of *Crossandra* (*Crossandra infundibuliformis L.)*

Treatments	Spike length (cm)				No. of spikes per plant				
	60 Dap	90 Dap	150 Dap	180 Dap	60 Dap	80 Dap	90 Dap	150 Dap	180 Dap
T_1	4.79	6.08	8.57	9.84	1.99	3.42	5.94	8.61	11.79
T_2	4.32	5.62	8.11	9.38	1.76	2.69	5.01	7.16	10.28
T_3	4.22	5.51	7.99	9.26	1.70	2.57	4.91	6.94	10.08
T_4	5.26	6.55	9.02	10.29	2.45	4.89	7.84	11.52	13.34
T_5	5.78	7.02	9.49	10.78	3.14	5.25	8.31	12.23	16.42
T_6	5.02	6.31	8.79	10.07	2.22	3.78	6.42	9.34	12.60
T_7	4.55	5.85	8.34	9.61	1.76	3.05	5.48	7.88	11.03
T_8	3.98	5.27	7.76	9.01	1.61	2.21	4.45	6.22	9.37
T_9	5.52	6.78	9.26	10.53	2.67	4.52	7.36	10.81	14.15
T_{10}	6.03	7.25	9.75	10.02	2.91	4.14	6.89	10.07	14.91
T_{11}	3.74	5.11	7.63	8.89	1.56	2.11	4.33	5.99	9.12
SE.d	0.09	0.12	0.17	0.19	0.041	0.068	0.118	0.170	0.288
CD=(P=0.05)	0.19	0.25	0.35	0.40	0.085	0.143	0.246	0.356	0.601

DAP–days after planting.

Table 4: Effect of micronutrients on flower yiel/plant, flower yield/plot and flower yield/ha of *Crossandra* (*Crossandra infundibuliformis L.)*

Treatments	Flower yield/plant	Flower yield/plot	Flower yield/ha
T_1	41.51	1033.18	16.19
T_2	38.04	948.35	14.73
T_3	36.39	907.09	14.17
T_4	44.97	1118.06	17.64
T_5	48.43	1202.89	19.05
T_6	43.23	1075.61	16.91
T_7	39.72	990.77	15.46
T_8	34.66	864.66	13.46
T_9	46.69	1160.48	18.36
T_{10}	50.15	1245.28	19.75
T_{11}	33.01	822.66	12.83
SE.d	0.81	20.26	0.31
CD=(P=0.05)	1.69	42.27	0.66

Discussion

Different micronutrient treatments significantly influenced the flower character of *Crossandra*. The spike length (6.03, 7.25, 9.75 and 11.02cm respectively on 60th, 90th, 120th, 150th, and 180th days after planting respectively), maximum number of flower per spike (42.37 on 60th, 90th, 120th, 150th, and 180th days after planting respectively), length of the individual flowers (5.60 cm 60th, 90th, 120th, 150th, and 180th days after planting respectively), and hundred flower weight (12.45 g) were observed in the treatment T10 (0.5% ZnSO4+ 0.5% FeSO4 of foliar spray on 45th, 75th, and 125th DAP). The increased flowering attributes through the application higher concentration of zinc sulphate and ferrous sulphate which increases the activation of enzymes that are responsible for the synthesis of certain proteins. It is used in the formation of more number of branches which is essential in the formation of auxins, which help with growth regulation and stem elongation. The findings in the present study were also supported by Iftikhar *et al.* (2010) [3] in rose, Karuppaiah (2014) [4] in chrysanthemum.

However, the maximum number of spikes per plant (3.14, 5.25, 8.31, 12.23 and 16.42 on 60th, 90th, 120th, 150th, and 180th days after planting respectively) were observed in T5. Induce more number of flower per spike, might be due to the higher concentration of zinc sulphate and ferrous sulphate which suppresses the emergence of maximum number of spikes per plant. Micronutrients enhances the translocation of carbohydrates, minerals and amino acids from the site of the synthesis to the flowering tissue especially on flowers as reported Hardeep *et al*. (2003) [2] in tuberose, Naveen *et al*. (2009) [5] in African marigold and Ahmad and Qusium (2013) [1] concluded that application of micronutrients could help better to improve the flower and quality of combined effect of micronutrients present in the foliar concoction as reported by, Iftikhar *et al.* (2010) [3] in rose.

The maximum yield per plant (50.15 g/ha), yield per plot (1245.28 g/ha) and flower yield per hectare (19.75 kg) were observed in T10 followed by T5. The application 0.5% of ZnSo4 and 0.5% of FeSo4 may be due to the production of more number of leaves and branches per plant, and chlorophyll content through the treatment effect which in return increases the flower weight, more number of spikes per plant, number of flower per spike, and other attributes. The result of the present study is inagreement with findings of Senthamizhselvi *et al.* (2000) [7] in *Jasminum sambac* and Arivazhagan (2012) [6] in african marigold.

Conclusion

From the results, it is concluded that foliar spray **T_{10}** (RDF + 0.5% ZnSO4 + 0.5% FeSO4 of foliar spray on 45th, 90th, and 125th DAP) exhibited maximum value followed by **T_5** (RDF + 0.2% ZnSO4 + 0.2% FeSO4 of foliar spray on 45th, 90th, and 125th DAP) for all characters except number of spikes per plant. In respect to number of spikes per plant, the maximum value was achieved by **T_5** (RDF + 0.2% ZnSO4 + 0.2% FeSO4 of foliar spray on 45th, 90th, and 125th DAP) followed by **T_{10}** (RDF + 0.5% ZnSO4 + 0.5% FeSO4 of foliar spray on 45th, 90th, and 125th DAP). The increased flowering attributes through the application micronutrients may be due to the production of more number of leaves and branches per plant, and chlorophyll content through the treatment effect which in return increases the flower weight, more number of spikes per plant, number of flower per spike, and other attributes.

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