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Effect of bioregulators and Feso4 on growth, yield and quality of crossandra (*Crossandra infundibuliformis* L.)

Abstract

The present investigation on the "Effect of bioregulators and $FeSo_4$ on growth, yield and quality of crossandra *(Crossandra infundibuliformis L.)"* was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar during 2011-2013 in RBD with fourteen treatments and three replications. Fourteen treatment combinations were formed by foliar application of bioregulators *viz.,* triacontanol (10 and 20ppm), brassinosteroid (0.5 and 1.0 ppm), maleic hydrazide (500 ppm and 1000 ppm) and $FeSo_4$ (0.5%), individually and in combination with $FeSo_4$ 0.5% on 3rd, 6th and 12th MAP. The control was maintained with water spray. The biometric observations like plant height, stem girth, number of branches and leaves per plant, plant spread, leaf area, chlorophyll content, dry matter production, number of spikes per plant, spike length, number of flowers per spike, individual flower length, ten flowers weight, carotenoid and xanthophylls content, visual scoring, flower yield per plant and hectare and shelf life were recorded. The results revealed that the treatment combination of maleic hydrazide (MH) 500ppm+Ferrous sulphate 0.5% (T_8) was found to be the best in growth, yield and quality attributes followed by maleic hydrazide (MH) 500ppm (T_6).

Keywords: bioregulators, triacontanol, brassinosteroid, maleic hydrazide, $Feso_4$, crossandra

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Introduction

Crossandra *(Crossandra infundibuliformis L.)* is one of the important commercial flower which comes under the family "Acanthaceae". This is grown in tropical countries like India, Africa and Madagascar as a commercial crop. There are four different cultivars of the species, *viz.,* Orange, Lutea Yellow, Sebaculis Red and Delhi. of these, Delhi type is a triploid (2n=30), which produces attractive flowers of bright deep orange colour when compared to other cultivars. The flowers are also light in weight and have good keeping quality. These are used for making garland either alone or in combination with jasmine flowers. Using crossandra flowers in combination with jasmine is become increasing popularly in India, particularly in southern parts, because the jasmine flowers provide colour contrast and the desired fragrance. Therefore, its cultivation has expanded in non traditional area also. There is an ample scope to enhance the productivity of crossandra by adopting proper crop management techniques. Synthetic growth regulatory chemicals are becoming extremely important and valuable in commercial floriculture for manipulating growth and flowering of many ornamental plants with a view to have compact plant and also to stretch out or retard or boost the rate of plant growth, in order to supply their flowers at specific periods and to get more yield. Bioregulators and stimulants are reported to be potent chemicals for a broad range of horticulture crops.[1] Among the bioregulators, maleic hydrazide is used in flowering annuals and other ornamental plants to control their growth and to improve their flowering ability. Application of maleic hydrazide was found to be superior in increasing the number of laterals per plant and flower in African marigold.[2] Triacontanol is a naturally occurring plant growth promoter which can act as a photosynthesis enhancer. It will also increase cell division rates leading to production of larger root and shoot mass and also activate secondary messengers leading to enhance enzymatic activities in plants.[3] Brassinosteroids (BRs) are a class of polyhydroxysteroids which influence the diverse physiological process like embryogenesis, cell elongation, vascular differentiation, fertility, proton pump activation, photosynthesis, and adoptive response to environmental stress.[4] Iron plays a very important role in various enzymatic activities and chlorophyll synthesis. Availability of iron depends on soil as well as ambient temperature and also the moisture condition of soil.[5] Beneficial effect of $FeSO_4$ had been observed by earlier workers in gerbera.[6] Keeping above in view, the present investigation on growth, yield and quality of crossandra as influenced by bioregulators and $FeSo_4$ was carriedout.

Materials and methods

The experimental site is located at about 20 km west of Bay of Bengal at 11°24' North latitude and 79°41' East longitude and at an altitude of+5.79 m above MSL with the mean maximum temperature of 33.14°C, mean minimum temperature of 25.3°C, average relative humidity of 88% and annual rainfall of 1887mm. The physico-chemical analysis of the soil revealed that the soil is clay loam in texture with medium N (250.60 kg/ha^{-1}), low P_2O_5 (19.50 kg/ha^{-1}), medium K_2O (256.80 kg/ha^{1}) and a pH of 6.52. Fourteen treatments were laid out in Randomized Block Design with three replications. The details of treatment combinations are as follows. T_1-Control (water spray), T_2-Triacontanol 10ppm, T_3-Triacontanol 20ppm, T_4-Triacontanol 10ppm+ferrous sulphate 0.5%, T_5-Triacontanol 20ppm+ferrous sulphate 0.5%, T_6-Maleic hydrazide (MH) 500ppm, T_7-Maleic hydrazide (MH) 1000ppm, T_8-Maleic hydrazide (MH) 500ppm+ferrous sulphate 0.5%, T_9-Maleic hydrazide (MH) 1000ppm+ferrous sulphate 0.5%, T_{10}-Brassinosteroid 0.5 ppm, T_{11}-Brassinosteroid 1.0 ppm, T_{12}-Brassinosteroid 0.5 ppm+ferrous sulphate 0.5%, T_{13}-Brassinosteroid 1.0 ppm+ferrous sulphate 0.5%, T_{14}-Ferrous sulphate 0.5 %.

Forty five days old seedlings were transplanted in beds with a spacing of 60 cm x 30 cm. The common fertilizer dose of 50:25:125 kg NPK per ha was applied to all the treatments through Urea, SSP and MOP respectively. Bioregulators and $FeSo_4$ were applied as foliar spray as per treatment schedule on 3rd, 6th and 9th month after planting and the biometric observation were recorded on 12 MAP. The total chlorophyll content was estimated in a fully expanded third leaf from the tip by adopting the procedure of Yoshida et al.[7] and the xanthophyll and carotenoid contents of the flowers were estimated as per the procedure of Pathmanaban et al.[8] and Lewis[9] respectively.

Results and discussion

The results of the present study revealed that foliar spray of triacontanol, maleic hydrazide, brassinosteroid and ferrous sulphate individually and incombination significantly influenced the plants growth attributes (Table1). The plants which received the Triacaontanol 10 ppm+ferrous sulphate 0.5% (T_4) expressed the maximum plant height (84.51cm), followed by the treatment combination of Triacontanol 20 ppm+ferrous sulphate 0.5% foliar spray (T_5). The increased plant height might be due to the growth promoting ability of triacontanol.[3] The lowest plant height was observed in T_6 (Maleic hydrazide 500ppm). The reduction in plant height may be due to the fact that MH causes suppression of apical dominance by inhibiting the cell division.

Table 1 Effect of bioregulators and $FeSo_4$ on growth attributes of crossandra (*Crossandra infundibulifomis* L.)

Treatments	Plant height (cm)	Stem girth (cm)	Number of branches per plant	Number of leaves per plant	Plant spread (cm²) (North-South)
T_1-control (Water Spray)	66.78	4.11	5.16	65.71	77.11
T_2-Triacontanol 10ppm foliar spray on 3rd. 6th and 9th MAP	68.38	4.64	7.18	78.12	86.29
T_3-Triacontanol 20ppm foliar spray on 3rd. 6th and 9th MAP	69.21	4.97	6.71	79.65	87.78
T_4-Triacontanol 10ppm + ferrous sulphate 0.5% foliar spray on 3rd. 6th and 9th MAP	84.51	5.53	9.26	95.46	92.37
T_5-Triacontanol 20ppm + ferrous sulphate 0.5% foliar spray on 3rd. 6th and 9th MAP	83.61	5.87	10.47	101.38	89.82
T_6- Maleic hydrazide (MH) 500ppm foliar spray on 3rd , 6th and 9th MAP	61.75	6.24	11.65	116.39	92.55
T_7- Maleic hydrazide (MH) 1000ppm foliar spray on 3rd , 6th and 9th MAP	59.42	5.57	10.04	98.17	87.97
T_8- Maleic hydrazide (MH) 500ppm+ ferrous sulphate 0.5% foliar spray on 3rd, 6th and 9th MAP	62.48	6.59	12.49	124.78	93.18
T_9- Maleic hydrazide (MH) 1000ppm+ ferrous sulphate 0.5% foliar spray on 3rd, 6th and 9th MAP	64.47	5.45	9.47	105.23	83.91
T_{10}- Brassinosteriod 0.5 ppm foliar spray on 3rd,6th and 9th MAP	72.51	4.64	10.44	87.42	83.11
T_{11}- Brassinosteriod 1.0 ppm foliar spray on 3rd,6th and 9th MAP	75.62	4.56	8.25	97.16	86.57
T_{12}- Brassinosteriod 0.5 ppm +ferrous sulphat 0.5% foliar spray on 3rd,6th and 9th MAP	79.25	4.88	7.63	87.33	88.99
T_{13}- Brassinosteriod 1.5 ppm +ferrous sulphat 0.5% foliar spray on 3rd,6th and 9th MAP	80.42	5.36	7.83	92.48	88.48
T_{14} -ferrous sulphat 0.5% foliar spray on 3rd,6th and 9th MAP	79.92	4.40	8.29	98.63	86.92
S.Ed	0.075	0.001	0.296	0.121	0.320
CD= (P=0.05)	0.154	0.002	0.611	0.256	0.659

MAP – Month After Planting

The maximum stem girth (6.29 cm), number of branches per plant (12.49), number of leaves per plant (24.78) and plant spread (93.18 cm²), (Table 1) were recorded in T_8 (Maleic hydrazide 500 ppm+$FeSo_4$ 0.5%), followed by T_6 (Maleic hydrazide 500 ppm). It was interesting to note that MH increased the number of branches per plant as a result of contineous cell division of subapical meristem, which could be in agreement with the finding of Dani et al.[2] in African marigold. The application of MH which suppressed the apical dominance and increased the laterals. To support more branches in a moderate stature of plant, the plant changed its ideotype with a strong, stout base of stem. Similar findings were registered by Sharifuzzaman et al.[10] in chrysanthemum.

The leaf area and chlorophyll content of crossandra have a significant variation with the application of bioregulators (Figure l) (Figure 2). The maximum leaf area (54.42 cm²) was registered by T4 (57.42 cm²), followed by T_5 (51.55 cm²). The increased leaf area might be due to the growth promoting ability of triacontanol. The minimum values were recorded with MH treatments. The reduction in leaf area as a result of application MH could perhaps be due to the reduction in cell size and construction of cell through its inhibitory effect. The findings of this study are in conformity with the earlier reports of Kavitha[11] in jasmine. The increased chlorophyll content over the control was observed with T_8 (MH 500 ppm+ferrous sulphate 0.5% foliar spray on 3rd, 6lh and 9th MAP) (Figure 2). The significant variation in chlorophyll content among the treatments than the control might be due to the direct influence of bioregulators on chlorophyll metabolism and photosynthetic efficiency of the plant as opined by Tannirwal et al.[12] in chrysanthemum. Ferrous sulphate also acted as catalyst in formation of chlorophyll and several enzymes. Thus, the mixture of MH and $FeSo_4$ and their split application favoured the chlorophyll synthesis and more number of leaves per plant. Similar result was noted by Sharifuzzaman et al.[10] in chrysanthemum.

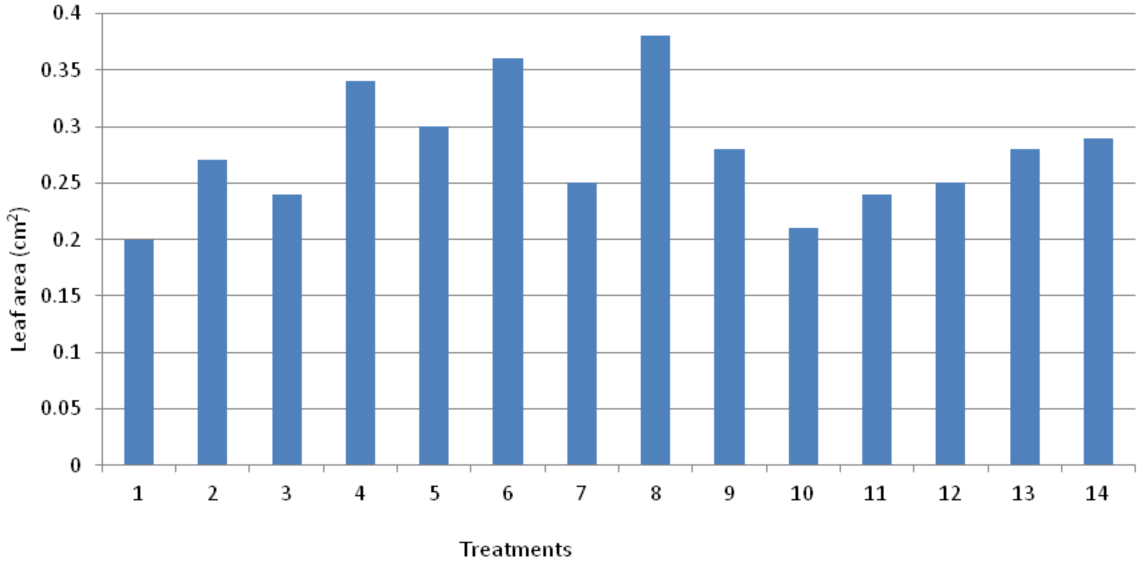

Figure 1 Effect of bioregulators and $FeSo_4$ on leaf area (cm^2) of crossandra (*Crossandra infundibulifomis* L.).

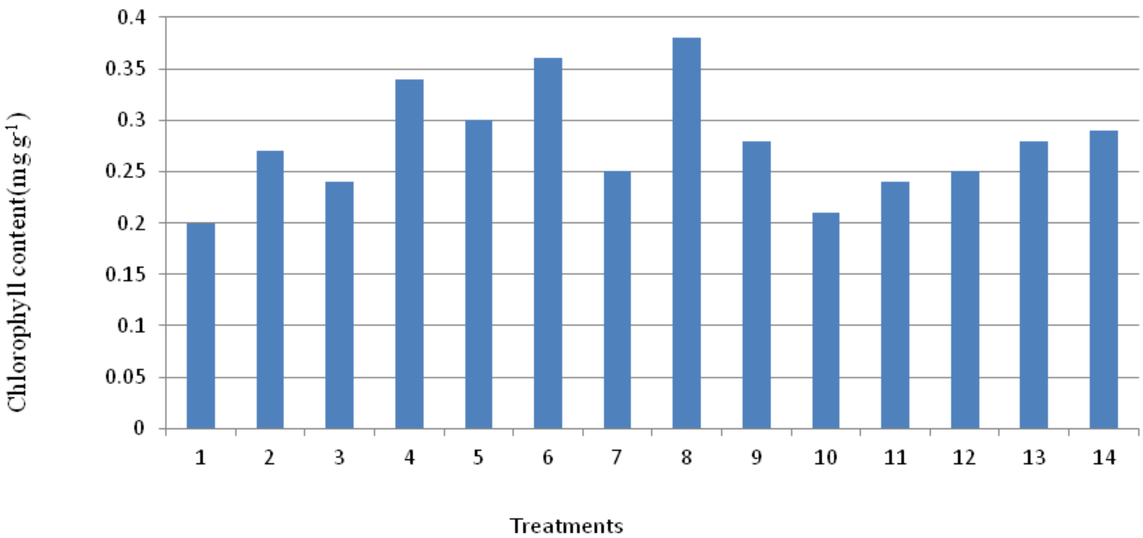

Figure 2 Effect of bioregulators and $FeSo_4$ on Chlorophyll content (mgg^{-1}) of crossandra (*Crossandra infundibulifomis* L.)

Different bioregulator treatments significantly influenced the flowering characters of crossandra. The maximum number of spikes per plant (19.25), spike length (9.25 cm), number of flowers per spike (31.01), length of individual flowers (5.2 cm) and ten flowers weight (1.295 g) (Table 2) were observed in the treatment T_8 (Maleic hydrazide (MH) 500 ppm+ferrous sulphate 0.5% foliar spray on 3rd, 6th and 9th MAP), followed by T_6. The increased flowering attributes through the application of MH and ferrous sulphate may be due to more number of branches and leaves per plant, and chlorophyll content through the treatments effect. The appropriate level of MH (500 ppm) might have moderately suppressed the apical dominance and favoured the branching of more laterals. The ferrous sulphate (0.5%) combination might have favoured the branches, leaf numbers and their development which intern resulted the more number of spikes per plant, number of flowers per spike, spike length and other yield attributes. Similar results reported by Kavitha[11] in Jasmine and Dani et al.[2] in marigold.

The maximum yield per plant (41.72 g) and flower yield per hectare (25.95q) (Table 3) were observed in T_8 followed by T_6. This might be due to the suppression of apical dominance which resulted in increased growth and flowering attributes which, ultimately favoured

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the flower yield. The result of the present study is in agreement with the finding of Mitali Saikia et al.[13] in chrysanthemum. With regard to quality' aspects *viz.,* visual scoring and shelf life (Table-3) xanthophyll and carotenoid content (Figure 3) the treatment T_8 was found to be excellent followed by T_6. Better quality crossandra flowers might be due to the appropriate level and combination of MH and ferrous sulphate. Increased flower shelf life through MH might be due to retarded metabolism and respiration. Similar effect of MH on extension of shelf life were recorded by Dutta et al.[1]

Table 2 Effect of bioregulators and $FeSo_4$ on flowering attributes of crossandra **(***Crossandra infundibuliformis* L.**)**

Treatments	Day taken to first flowering	Number of spikes per plant	Spike length (cm)	Number of flowers per spike	Ten flowers weight (g)	Length of individual flower (cm)
T_1	72.41	14.05	10.44	17.04	0.778	3.2
T_2	84.36	15.75	11.65	20.13	0.950	3.7
T_3	80.33	16.41	11.86	21.10	0.967	3.8
T_4	86.37	46.05	12.16	23.13	1.115	4.6
T_5	79.61	15.08	12.04	22.93	1.050	4.2
T_6	75.24	17.83	12.71	27.26	1.268	4.9
T_7	68.28	15.91	10.59	23.57	1.195	4.5
T_8	78.26	19.25	13.49	31.01	1.295	5.2
T_9	73.24	16.16	11.13	24.34	1.085	4.3
T_{10}	73.38	16.58	10.79	23.25	1.005	3.7
T_{11}	75.41	14.91	10.53	24.51	1.055	3.9
T_{12}	78.28	15.26	10.63	25.45	0.845	4.0
T_{13}	76.46	15.28	10.66	21.74	0.995	4.2
T_{14}	79.50	14.91	10.70	25.77	1.050	3.8
S.Ed	0.061	0.352	0.316	0.901	0.405	0.218
CD=(P=0.05)	0.126	0.725	0.652	1.858	0.835	0.449

Table 3 Effect of bioregulators and $FeSo_4$ on yield and quality attributes of crossandra (*Crossandra infundibuliformis* L.)

Treatments	Flower yield per plant (g)	Plot yield (g $plot^{-1}$)	Flower yield per hectare (q ha^{-1})	Visual scoring	Shelf life (hours)
T_1	21.32	511.68	7.73	6.12	39.31
T_2	24.69	592.56	9.88	6.80	42.68
T_3	26.94	646.56	10.78	7.06	43.53
T_4	30.45	730.80	12.18	8.68	53.55
T_5	34.81	835.44	13.92	8.22	54.70
T_6	42.85	1028.40	17.14	8.82	57.81
T_7	38.29	934.08	15.57	8.19	52.44
T_8	46.72	1124.28	18.74	9.19	58.66
T_9	39.46	947.07	15.78	7.79	44.85
T_{10}	32.86	788.64	13.14	7.74	41.74
T_{11}	33.51	804.24	13.40	7.66	42.56
T_{12}	36.41	973.84	14.56	6.99	47.03
T_{13}	39.69	952.56	15.96	1.02	48.48
T_{14}	33.50	804.00	13.40	7.52	44.53
S.Ed	**0.296**	**2.717**	**0.024**	**0.036**	**0.077**
CD = (P=0.05)	**0.611**	**5.598**	**0.049**	**0.075**	**0.158**

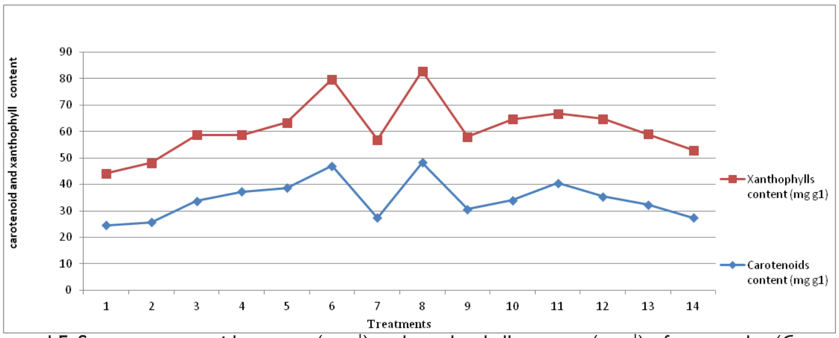

Figure 3 Effect of bioregulators and $FeSo_4$ on carotenoid content (mgg^{1}) and xanthophyll content (mgg^{1}) of crossandra (*Crossandra infundibuliformis L.*)

From the result, it is concluded that foliar spray of Maleic hydrazide 500 ppm+ferrous sulphate 0.5% on 4th, 8th and 12th MAP resulted in better growth, higher flower yield as well as quality of crossandra under open field cultivation.

Acknowledgments

None.

Conflicts of interest

Authors declare that there is no conflicts of interest.

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