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Coupling effect of fertigation and foliar application of micronutrients on growth, yield and quality of carnation (*Dianthus caryophyllus*) cv Bizet

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ABSTRACT

Investigation was undertaken to study the effect of fertigation and foliar application of micronutrients on growth, yield and flower quality of carnation (*Dianthus caryophyllus* L.) cv Bizet under naturally ventilated polyhouse at Nilgiris (Ooty) in Tamil Nadu during April 2012 to May 2013. The experiment consisted of nine micronutrient treatments and it was laid out in randomized block design with three replications. $ZnSO_4$, $FeSO_4$, $CuSO_4$, Borax and chelated micronutrient EDTA mix (MN-EDTA) were given in different combinations through fertigation and/or foliar application. The effect of these micronutrients on vegetative growth, yield, quality was evaluated at critical crop growth stages. Results revealed that fertigation of 0.4% MN-EDTA+ foliar application of 0.2% MN-EDTA at fortnightly intervals, beginning from one month after planting up to harvesting stage significantly improved plant height (94.89 and 85.94 cm), number of leaves (184.62 and 215.98), number of laterals (6.8 and 9.4), earliness in flower bud appearance (94.75 and 80.20 days), stalk length (81.23 and 76.31 cm), yield (243.57 and 323.73 flowers/m^2) and vaselife (16.20 and 16 days) during the two consecutive flushes, respectively.

Key words: Carnation, Fertigation, Foliar application, Growth, Micronutrients, Quality, Yield

Carnation (*Dianthus caryophyllus* L.), a member of Caryophyllaceae family is the native of Mediterranean region. It is one of the most important commercial cut flowers of the world with immense export potential. Besides its usage as a cut flower, floral arrangement and corsages, it is also grown in beddings, pots and as a border plant. A wide range of colours and forms, excellent keeping quality, ability to withstand long distance transport and characteristic to rehydrate after continuous shipping makes this flower highly valued among the growers.

Micronutrients are involved in metabolic and cellular functions like energy metabolism, primary and secondary metabolism, hormonal synthesis and signal transduction cascades (Hansch and Mendel 2009). In recent years, the crop requirement for micronutrients is gaining momentum among flower growers because of their potential to enhance yield with better quality. When micronutrients like iron, copper, zinc, molybdenum, magnesium, manganese and boron are applied directly as inorganic salts, they are converted to insoluble forms, not readily available for plant uptake. Hence, chelated forms of micronutrients are recommended for better yields. The chelating agent protects the metal ions from undesirable chemical reactions such as precipitation and hence increases the availability of these metal ions to plants (Datir *et al*. 2012). EDTA is the most common synthetic chelating agent used for both soil and foliar applied nutrients.The application of chelated micronutrient fertilizers to soil or foliar spray helps in easy absorption, translocation and bioavailability of mineral nutrients. They play an important role in carnation to get good quality flowers, which are free from physiological disorders like calyx splitting, slabside and calyx tip dieback. Foliar feeding of nutrients improves nutrient utilization and reduces environmental pollution by decreasing dependence on soil application of fertilizers (Roemheld and El-Fouly 1999). Fertigation also reduces the wastage of nutrients through enhanced fertilizer use efficiency, besides providing flexibility in timing of fertilizer application according to crop demand at specific growth stage (Papadopoulos 1992). Hence, the present study was undertaken with an objective to work out an appropriate dose and right method of fertilizer application that results in optimum yield and quality of carnation.

MATERIALS AND METHODS

The experiment was conducted at Ooty, Tamil Nadu during 2012-13 under naturally ventilated Gothic type of

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polyhouse. Carnation cv Bizet plants were grown with nine different micronutrient regimes, laid out in randomised block design with three replications. Treatment combinations comprised of T_1: Fertigation of 0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% $CuSO_4$ + 0.1% Borax, T_2: Foliar application of 0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% $CuSO_4$ + 0.1% Borax, T_3: Fertigation of 0.2% EDTA-Micronutrient mix (MN-EDTA),T_4: Fertigation of 0.4% MN-EDTA, T_5: Foliar application of 0.2% MN-EDTA, T_6: Foliar application of 0.4% MN-EDTA, T_7: Fertigation of 0.2% MN-EDTA + foliar application of 0.4% MN-EDTA, T_8: Fertigation of 0.4% MN-EDTA + foliar application of 0.2% MN-EDTA and T_9: Control with nil application of micronutrients.

The experimental field was ploughed with power tiller to ensure fine tilth, soil aeration and effective drainage. Raised beds of 1.0 m width, 6 m length and 30 cm height with a footpath of 40 cm were prepared. Beds were fumigated with Dazomet at the rate of 30 g/m and covered with polythene sheet for 7 days, after which the beds were copiously irrigated to leach out the chemical residue. The experimental plots were applied with growing media consortia of well decomposed farmyard manure (25 kg/m), cocopeat (2.5 kg/m), vermicompost (2.5 kg/m), and neem cake (500 g/m). Inorganic nutrients were supplied through single superphosphate (200 g/m), muriate of potash (150 g/m) and $MgSO_4$ (50 g/m). Healthy rooted cuttings (28 days old) of standard cultivar 'Bizet' was planted in raised beds with the spacing of 15 × 15 cm^2 accommodating 36 plants/m. Micronutrients were given over and above the 100% recommended dose of fertilizers. $ZnSO_4$, $FeSO_4$, $CuSO_4$, Borax, MN-EDTA (chelated micronutrient mix comprising Fe 3% + Mn 1.5% + Zn 5.5% + Cu 0.1% + B 0.1%) were applied at fortnightly intervals, beginning from pinching up to harvesting stage. Fertigation was given by mixing the micronutrients as per the treatment schedule and foliar application was given by mixing these elements along with surfactant (Teepol 0.05%). The plots receiving foliar application were sprayed till runoff point (2.5 l/m). Other recommended cultural operations were carried out to ensure optimum plant growth and development. Data related to morphological, flowering, yield and quality parameters were recorded during two consecutive flushes. Statistical analysis was carried out by adopting the standard procedures of Panse and Sukhatme (1985) and the critical difference was worked out at five per cent probability.

RESULTS AND DISCUSSION

Morphological parameters

The results presented in Fig 1 revealed that the treatments significantly affected plant height at different stages of crop growth. Enhancement in plant growth is rapid after pinching, with a visual sign of increased plant height from 30 to 180 days after planting (DAP). Maximum plant height was at peak flowering stage (210 DAP), following with a decline was observed at 240 DAP as the flower stalks are harvested up to fifth node during the first flush. It takes five months for a plant to attain a maximum height for yielding the second flush. Fertigation with 0.4% MN-EDTA + foliar application of 0.2% MN-EDTA (T_8) resulted in maximum plant height (94.89 and 85.94cm in the first and second flushes at 210 and 360 DAP, respectively), followed by T_5. The least plant height (74.91 and 59.16 cm at 210 and 360 DAP respectively) was recorded in control. Availability of adequate moisture content at the root zone and easy absorption of chelated nutrients in T_8 might have helped plants to attain maximum plant height (Patil and Janawade 1999). Improvement in growth characters due to micronutrient application might be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation (Halder *et al*. 2007). Surendra and Navvalagatta (2006) also observed the same trend of results for plant height in bhendi supplemented with "Multiplex", a micronutrient formulation containing Zn, Cu, Fe, Mn, B and Mo.

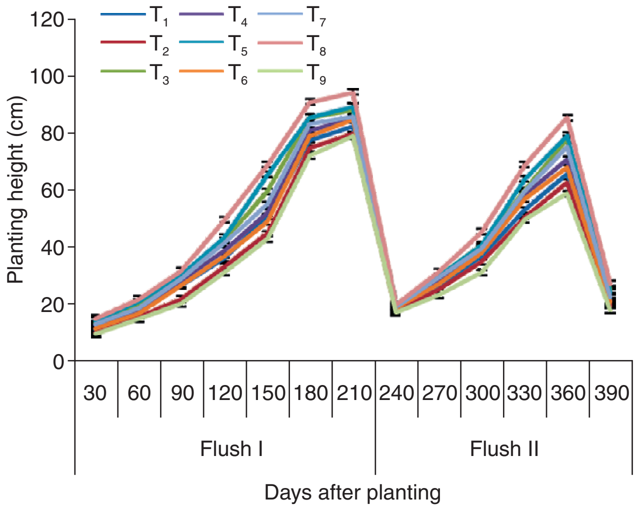

Fig 1 Effect of micronutrients on plant height of carnation cv. Bizet

Number of leaves/plant is one of the most important characters contributing to carbohydrate metabolism and photosynthetic efficiency. The number of leaves/plant was significantly enhanced in T_8. Increase in leaf number might be due to continuous availability of micronutrients leading to improved protein synthesis, hormonal translocation and nitrogen metabolism. Zinc and boron are particularly implicated in increasing leaf production. Results in the present study are supported by Chaturvedi *et al.* (1988) in gladiolus, Barman and Pal (1993) and Nath and Biswas (2002) in tuberose.

During the first flush, the side branches started to appear at 30 DAP (after pinching), reached to maximum number at 150 DAP and thereafter declined (180 and 210 DAP) when flower stalks were harvested (paint brush stage). More number of laterals was observed in the second flush as the plant already contained 4 to 6 well established stubs facilitating the effective utilization of applied nutrients. Laterals are important in carnation, as they are the source of cuttings required for plant propagation. Increase in number of laterals at early vegetative phase and its sustenance up to the reproductive stage is a good sign for higher flower yield. The treatment T_8 (Fertigation of 0.4% MN-EDTA + foliar application of 0.2% MN-EDTA) excelled among others with a maximum of 6.7 and 9.4 followed by T_5 with 6.4 and 8.8 laterals during the first and second flush, respectively. Least number of branches per plant was recorded in control with 5.5 and 5.8. The results are in accordance with Aruna (1999) in crossandra, where iron has been reported to play a role in the production of laterals. Khan (2000) reported that increase in number branches per plant in dahlia might be due to the combined effect of zinc and iron nutrition.

Yield parameters

Yield attributing characters like bud appearance and bud opening have a definite role in the successful commercial cultivation of carnation. Days to flower bud appearance and earliness in flowering are vital characters apart from other quality aspects in clinching the market. Significant variation was noticed for flower bud appearance and days taken for bud opening (Table 1). Fertigation with 0.4% MN-EDTA + foliar application of 0.2% MN-EDTA (T_8) recorded the earliest flower bud appearance with 94.75 and 80.20 days and bud opening with 120.24 and 110.68 days after planting during the first and second flushes respectively. It was followed by T_5 with 100.46, 85.36 days for bud appearance and 128.06, 119.80 days for bud opening during first and second flushes, respectively. T_9 (Control) lagged behind with 118.96 and 109.84 days in concern with bud appearance and 156.36 and 139.69 days for flower opening throughout the two flushes respectively. The superior effect of T_8 might be due to interaction of micronutrients which are the constituent of proteins, amino acids, nucleic acids, various enzymes and coenzymes which are associated with the increased shoot length and leaf area resulted in more photosynthesis and thus increased the transformation of manufactured food material from source (leaf) to sink (flower bud). This was in conformity with Marschner (1983), Chaturvedi *et al*. (1988) in gladiolus and El Naggar (2009) in carnation. Further, it was concluded that Zinc favouring the storage of more carbohydrates through photosynthesis, which might be the attributing factor for the positive effect of ferrous sulphate on flowering (Senthamizhselvi 2000 in *Jasminum sambac*; Jauhari *et al*. 2005 in gladiolus). Flowering in rose was initiated by manganese (Bhattacharjee and Singh 1992) and in chrysanthemum by zinc and boron (Misra 2001).

The maximum cut flower yield/m (243.57 and 323.73 flowers) was obtained from fertigation with 0.4% MN-EDTA + foliar application of 0.2% MN-EDTA (T_8), whereas the minimum yield obtained under control with 151.00 and 178.40 flowers through the first and second flush, respectively. The interactive effect of micronutrients at early phase of growth influences production of auxin and growth substances, which might have contributed to the formation of more number of floral buds as reported in chrysanthemum (Lalitha Kameswari *et al*. 2009) and *Rosa*

Table 1 Effect of weed control methods on species wise weed density (No/m^2) in transgenic and conventional corn hybrids (60 DAS)

Treatment	Number of leaves		Number of laterals		Flower bud appearance (day)		Flower opening (day)		Number of flowers m^{-2}		Stalk lengh (cm)		Stalk girth (cm)		Vase life (cm)	
	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2
T_1	157.3	179.1	5.9	6.2	110.2	101.6	143.8	129.5	196.2	218.3	66.86	64.32	1.59	1.55	12.5	12.2
T_2	152.2	171.5	5.2	6.7	111.2	102.9	147.5	132.3	173.4	205.0	63.12	62.16	1.6	1.54	122.5	12.2
T_3	168.4	200.1	6.6	7.4	101.2	89.87	133.9	122.4	215.2	256.2	73.54	72.3	1.86	1.83	12.3	12
T_4	163.4	191.2	6.2	7.3	107.2	95.69	140.5	127.2	206.9	237.5	69.46	68.96	1.72	1.68	14.5	14.2
T_5	169.2	206.9	6.4	8.8	100.5	85.4	128.1	119.8	222.4	298.9	77.42	72.15	1.93	1.9	13.2	13.1
T_6	162.0	185.6	6.4	6.2	108.2	98.5	140.8	128.5	201.0	240.3	68.54	65.12	1.68	1.6	15	14.5
T_7	166.0	194.3	6.5	6.4	104.6	92.1	138.2	124.7	210.8	231.6	72.16	71.5	1.84	1.8	12.1	12.5
T_8	155.4	216.0	6.7	6.4	94.8	80.2	120.2	110.7	243.6	323.7	81.23	76.31	1.98	1.94	14.1	13.8
T_9	134.3	160.3	5.5	5.8	119.0	109.8	156.4	139.7	151.0	178.4	62.1	59.39	1.35	1.3	16.2	16
Mean	158.7	189.5	6.16	7.1	106.2	95.1	138.8	126.1	202.3	243.3	70.03	68.02	1.74	1.68	11	10.5
SE (d)	3.88	3.89	0.16	0.18	2.6	2.34	3.46	3.13	5.16	6.28	1.78	1.67	0.04	0.03	13.43	0.35
CD (P=0.05)	8.23	8.24	0.33	0.39	5.51	4.97	7.34	6.64	10.94	13.31	3.78	3.55	0.09	0.08	0.69	0.74

hybrida (Adnanyounis *et al*. 2013). Further, reduced nutrient leaching and efficient use of nutrients during fertigation might have a singnificant influence on yield attributes, as also observed in gerbera (Shrikant 2008) and *Rosa hybrida* (Qasim *et al.* 2008).

Quality parameters

Flower quality can be assessed by evaluating the product either subjectively or objectively. Subjective evaluation of floral quality includes colour, fragrance, cleanliness and form whereas characteristics such as flower diameter, disc diameter, stalk length and stalk girth constitute parameters for objective evaluation of quality (Salunkhe *et al*. 1990). One of the essential requirements in cut flower production is the stalk length. Stalk girth is an important parameter in carnation as it indicates the plants' ability to sustain the flower weight, thereby determining post-harvest life. Conjunctive application of fertigation and foliar spray of chelated micronutrient mix (T_8) enhanced the stalk length (23 and 22.17%) and girth (32.9 and 31%) as compared to the control in the two consecutive flushes respectively. Improved length and girth of flower stalk might be due to enhanced photosynthetic support optimized by the presence of zinc, boron and other micronutrients. Similar effects were documented in gladiolus (Kumar and Arora 2002).

Vase life determines the commercial value of cut flowers. It assumes greater significance in flowers like carnation which is highly sensitive to ethylene. Variation in vase life among the treatments might be attributed to differential accumulation of carbohydrates. Longest vase life (16.20 and 16 days) was obtained from T_8 and the shortest was noticed from T_9 (11 and 10.50 days) during the two subsequent flushes, respectively. Similar results were obtained in gerbera supplemented with a micronutrient formulation "Multiplex" (Bhagyalakshmamma 1998). Continuous supply of micronutrients would have helped in maintenance of turgor in the leaf and flower, which in turn extended the vaselife of carnation as reported by Mukund *et al.* (2004).

The present investigation revealed that the parameters related to growth, yield and quality responded to fertigation and foliar spray of micronutrients. Plants that received a combination of 0.4% fertigation and 0.2% foliar application chelated micronutrient EDTA at fortnightly intervals from pinching up to harvesting stage exhibited significantly superior traits among other treatment combinations, resulting in higher cut flower yield and better quality in carnation cv. Bizet.

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REFERENCES

Adnanyounis, Riaz A, Sajid, Mushtaq N, Ahsan M, Hameed M, Tariq U and Nadeem M. 2013. Foliar application of macro and micronutrients on the yield and quality of *Rosa hybrida* cvs. Cardinal and Whisky Mac. *African Journal of Biotechnology* **12**(7): 702–08.

Aruna, P. 1999. Yield and physiological response to nitrogen levels and micronutrients in crossandra (*Crossandra infundibuliformis* L. Ness.) Ph.D., dissertation, Tamil Nadu Agricultural University, Coimbatore.

Barman D and Pal P. 1993. A note on effect of micronutrients on growth and yield of tuberose cv. Single. *Horticulture Journal* **6**(1): 69–70.

Bhagyalakshmamma B S. 1998. Effect of micronutrients on growth, yield, quality and post harvest life of gerbera (*Gerbera jamsonii* Hook.) grown under cover. M Sc (Hort.) dissertation,*University of Agricultural Sciences,* Bengaline.

Bhattacharjee S K and Singh U L. 1992. Response of micronutrient spray on growth, flowering, flower quality and yield of Raktagandha roses. *Orissa Journal of Horticulture* **20**(2): 58–63.

Chaturvedi O P, Shukla I N, Singh A R and Shukla H S.1988. Effect of agromin on growth and corm production of gladiolus. *Haryana Journal of Horticultural Sciences* **17**(13–14): 130–34.

Datir R B, Apparao B J and Laware S L. (2012). Application of amino acid chelated micronutrients for enhancing growth and productivity in chilli (*Capsicum annum* L.). *Plant Sciences Feed* **2**(7): 100–05.

El-Naggar and A H. 2009. Response of *Dianthus caryophyllus* L. plants to foliar nutrition. *World Journal of Agricultural Sciences* **5**(5): 622–30.

Halder N K, Rafiuddin Md, Siddiky M A, Gomes R and Kabita Anzu-Man-Ara Begam. 2007. Performance of gladiolus as influenced by boron and zinc. *Pakistan Journal of Biological Sciences* **10**(4): 581–85.

Hansch R and Mendel R R. 2009. Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). *Current Opinion in Plant Biology* **12**: 259–66.

Jauhari S, Srivastava R and Srivastava P C. 2005. Effect of zinc on growth, flowering, corm attributes, post-harvest life and leaf and corm nutrient status in Gladiolus cv. Red Beauty. *Progressive Horticulture* **37**(2): 423–28.

Khan F U. 2000. Effect of micronutrients on Dahlia. *Journal of Ornamental Horticulture, New Series* **3**(2): 122–23.

Kumar P and Arora J S. 2002. Effect of micronutrients on gladiolus. *Journal of Ornamental Horticulture* **3**(2): 91–93.

Lalithakameswari M, Pratap and Padmavathamma A S. 2009. Effect of foliar spray of micronutrients on growth and flowering of Chrysanthemum (*Dendranthema grandiflora* Tzvelev). *The Orissa Journal of Horticulture* **37**(2): 26–29.

Marschner H. 1991. *Mineral Nutrition of Higher Plants*, Academic Press, London.

Misra H P. 2001. Response of chrysanthemum to zinc and boron on growth, yield and quality of flowers. *Scientific Horticulture* **7:** 201–08.

Mukund S, Shirol A M, Reddy B S and Kulkarni B S. 2004. Performance of standard carnation (*Dianthus caryophyllus* L) cultivars under protected cultivation for vegetative characters. *Journal of Ornamental Horticulture* **7**: 212–16.

Nath M R and Biswas J. 2002. Studies on effect of boron on vegetative and reproductive growth in tuberose (*Polianthes* *tuberosa* L.) cv. Single. *The Orissa Journal of Horticulture* **30**(2): 39–42.

Panse V G and Sukhatme P V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Papadopoulos I. 1992. Fertigation in Cyprus and some other countries of the Near East region: present situation and future prospects. IAEA workshop, 7-11 September 1992, Ankara, Turkey.

Patil V S and Janawade A D. 1999. Soil water plant atmosphere relationships. (*In*) *Proceedings of Advances in Microirrigation and Fertigation*, June 21-30, Dharwad, Karnataka, pp 19–32.

Qasim I, Ahmad and Ahmad T. 2008. Optimizing fertigation frequency for *Rosa hybrida* L. *Pakistan Journal of Botany* **40** (2): 533–45.

Salunkhe D K, Bhat N R and Desai B B. 1990. *Post Harvest Biotechnology of Flowers and Ornamental Plants*, pp 36–41. Springer-Verlag Berlin Heidelberg.

Senthamizhselvi B. 2000. Studies on the flowering and productivity of Gundumalli (*Jasminum sambac* Ait) as influenced by nutrient management techniques. M Sc (Hort.) dissertation, *Tamil Nadu Agricultural University*, Coimbatore.

Shrikant M. 2008. Effect of fertigation and biostimulants on Gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) var. Debora under polyhouse conditions. M Sc (Hort.) dissertation,Tamil Nadu Agricultural University, Coimbatore.

Surendra and Navvalagatta. 2006. Effect of plant growth regulators and micronutrients on morphological and biochemical traits and yield in Okra. *Journal of Agricultural Science* **19(3)**: 694–97.

Roemheld V and El-Fouly M M 1999. Foliar nutrient application Challenge and limits in crop production. *Proceedings of the 2nd International Workshop on Foliar Fertilization*, Bangkok, Thailand, pp 4–10.