Original Research Article

Effect of micronutrients (Boron & Zinc) on growth, flowering and quality of carnation (*Dianthus caryophyllus* L.) under naturally ventilated polyhouse conditions of Prayagraj

ABSTRACT

The present investigation entitled **Effect of micronutrients (Boron & Zinc) on growth, flowering and quality of carnation (*Dianthus caryophyllus* L.) under naturally ventilated polyhouse conditions of Prayagraj** was carried out in naturally ventilated polyhouse, Department of Horticulture, SHUATS, Prayagraj during November, 2021 – May, 2022. The experiment was conducted in Randomized Block Design (RBD) with fifteen treatments replicated thrice. Foliar application with three levels of boron (0.05%, 0.1% and 0.15%), three levels of zinc (0.2%, 0.4%, and 0.6%) and treatment combinations of both boron and zinc alongwith control were applied. Among all the treatments, treatment T_2 (B @ 0.1%) recorded significantly taller plants (84.71 cm), more number of leaves (165.47), more number of shoots (7.53), more number of internodes (17.27), higher internodal length (5.21 cm), longer bud (3.63 cm), more bud diameter (2.33 cm), higher flower stalk girth (4.86 mm) and more vase life (11.2 days). However, treatment T_6 (Zn @ 0.6 %) exhibited early days for bud initiation (124.27 days), bud opening (14.47 days), 50 percent flowering (138.73 days), more number of cut flower stalks per plant (7.13) and more number of flowers per meter square (178.33) while treatment T_5 (Zn @ 0.4 %) exhibited longer flower stalk (66.23 cm) and treatment T_{10} (B @ 0.1 % + Zn @ 0.2 %) produced good flower diameter (6.62 cm). Poor flowers were generated by plants that were not given micronutrients. So, T_2 (B @ 0.1 %) and T_6 (Zn @ 0.6 %) can be applied topically to improve the quality of flowers. Micronutrient foliar applications are proven to be crucial for improving the vegetative growth, flowering, quality and yield parameters of carnation grown under naturally ventilated polyhouse conditions of Prayagraj.

Key words*: *carnation, polyhouse, micronutrient, boron, zinc

1. INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) is one of the most important and an excellent cut flower crops grown in almost all the countries of the world and ranks second on global floriculture screen **(Patil *et al*., 2004)**. Carnation is the national flower of Spain, is native of the Mediterranean region and belongs to the family Caryophyllaceae. Carnations are preferred than roses and chrysanthemums by some countries for export due to its beauty and forms, its excellent keeping quality, wide range forms and colors and ability to withstand long distance transportation. The importance of major and micronutrients in Indian agriculture is truly well recognized and their use had significantly contributed to the increased productivity of several crops. Both macro and micronutrients have great bearing in influencing the yield attributes of most of the flowering plants **(Abdul *et al*., 1985).** Micronutrients are involved in all metabolic and cellular functions. Improvement in growth characters due to micronutrient application might basically be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation **(Hatwar *et al*., 2003).**

Quality is one of the most important characters in the cut flower industry and this is influenced by application of nutrients **(Belgaonhar *et al*., 1997).** But carnation growers often faced a problem of severe calyx splitting due to boron deficiency. On the other hand, excess boron has been found toxic to the plants which expresses as leaf tip burn symptoms. Therefore, there is a need to standardize the dose of boron so that it controls calyx splitting. Boron, the non-metal compound plays an essential role in the growth and development of new cells in the plant meristem. It is a micronutrient of special importance because of its role in the fertilization and flowering process. The stunted growth, poor development, delayed maturity and little leaf of the plant is found to be low in zinc. Zinc, as a micronutrient, is indispensable for proper growth and development of plants **(Khosa *et al.*, 2011).** It is effective in plant nutrition for the synthesis of plant hormones and balancing intake of P and K inside the plant cells. Carnation flowers are popular among the commercial cut flowers appearing in floral arrangements, corsages, and boutonnieres. As one of the fourth important cut flowers in the world, carnation's quality is crucial in order to compete in both the domestic and international markets and this is influenced by the application of nutrients. Carnations with good strongest stem length, large buds, no calyx splitting, early maturity and longer post-harvest life are more expensive in the global market. So in view of the mentioned facts, the present study was undertaken to standardize the correct dosage of boron and zinc through foliar application.

2. MATERIALS AND METHODS

This experiment was carried out in the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj, to study the effect of foliar application of boron, zinc and their combination in carnation plant under naturally ventilated polyhouse conditions of Prayagraj. This experiment was set up in a Randomized Block Design (RBD) with three replications. Treatments were applied by using hand operated sprayer at monthly interval starting from first month after planting. Healthy, rooted terminal cuttings of standard carnation were planted in naturally ventilated polyhouse with the spacing of 20 cm × 20 cm and after 25 days of planting single pinching were carried out. Vegetative parameters *viz.*, plant height (cm), number of leaves, number of shoots per plant, number of internodes per shoot and internodal length (cm); floral & quality parameters *viz.*, days taken to bud initiation, days taken to bud opening, days taken to 50% flowering, bud length (cm), bud diameter (cm), flower stalk length (cm), flower stalk girth(mm) and vase life (days); and yield parameters *viz.*, number of cut flower stalks per plant and number of flowers per meter square were recorded during the experimental period from tagged plants and expressed accordingly in centimeters (cm), millimeters (mm), numbers and days. The flowers were harvested at paint-brush stage and a slant cut was given at the bottom end of the flower stalk using a pair of secateurs then placed in a bucket containing clean water to remove field heat.

Table 1. Treatment details

T_0	Control (water spray)

T_1	B @ 0.05 %
T_2	B @ 0.1 %
T_3	B @ 0.15 %
T_4	Zn @ 0.2 %
T_5	Zn @ 0.4 %
T_6	Zn @ 0.6 %
T_7	B (0.05 %) + Zn (0.2 %)
T_8	B (0.05 %) + Zn (0.4 %)
T_9	B (0.05 %) + Zn @ (0.6 %)
T_{10}	B (0.1 %) + Zn (0.2 %)
T_{11}	B (0.1 %) + Zn (0.4 %)
T_{12}	B (0.1 %) + Zn (0.6 %)
$T1_3$	B (0.15 %) + Zn (0.2 %)
T_{14}	B (0.15 %) + Zn (0.4 %)
T_{15}	B (0.15 %) + Zn (0.6 %)

3. RESULT AND DISCUSSION

I. VEGETATIVE PARAMETERS

Plant height (cm): Plant height of carnation varied significantly among the treatments at 120 days after planting. T_2 produced the tallest plants (84.71 cm) followed by T_1 (80.28 cm) whereas the shortest plant height was obtained from T_0 (63.04 cm). The differences in plant height (cm) per plant may be due to the uptake of boron in sufficient quantities at the critical development and also might have been due to favourable role of boron in N metabolism, cell division and expansion in the different phases of growth reported by **Russel, (1957)**. Similar observations were reported by **Rajput *et al.,* (2003)** in African marigold.

Number of leaves: The maximum number of leaves was recorded from T_2 (165.47) followed by T_1 (161.87) and T_0 (143.93) obtained the lowest number of leaves per plant at 120 days after planting. This might due to the fact that the optimum dose of boron which besides being involved in the formation of cell wall, also gets tied up with the protein in the protoplasm and accumulation of simple carbohydrate and nitrogen compounds in plant which are the prime necessities for the formation of leaves. Similar findings were reported by **Balakrishnan (2001), Kumar *et al.*, (2010)** and **Khan *et al.* (2012).**

Number of shoots per plant: Maximum number of shoots per plant was found in T_2 (7.53) followed by T_1 (7.33), whereas less numbers of shoots per plant were obtained in T_0 (6.67) at 120 days after planting. This might have been due to favourable role of boron in N metabolism,

Table 2.1 Effect of boron and zinc on various vegetative parameters of carnation

Treatments	Plant height (cm)	Number of leaves	Number of shoots per plant	Number of internodes per shoot	Internodal length (cm)
T_0 (Control)	63.04	143.93	6.67	16.07	3.96
T_1 (B@0.05%)	80.28	161.87	7.33	17.07	5.17
T_2 (B@0.1%)	84.71	165.47	7.53	17.27	5.21
T_3 (B@0.15%)	74.53	156.00	7.13	16.73	4.93
T_4 (Zn@0.2%)	72.61	151.07	7.07	16.67	4.63
T_5 (Zn@0.4%)	78.14	158.60	7.33	16.93	5.13
T_6 (Zn@0.6%)	79.61	160.13	7.33	17.00	5.14
T_7 (B@0.05% + Zn@0.2%)	77.08	158.13	7.33	16.93	5.07
T_8 (B@0.05% + Zn@0.4%)	74.23	155.20	7.13	16.67	4.85
T_9 (B@0.05%+ Zn@0.6%)	75.21	156.67	7.20	16.73	4.95
T_{10} (B@0.1% + Zn@0.2%)	75.90	157.33	7.20	16.73	5.04
T_{11} (B @ 0.1% + Zn @ 0.4%)	74.01	154.67	7.07	16.67	4.73
T_{12} (B @ 0.1% + Zn @ 0.6%)	71.08	150.73	7.00	16.53	4.57
T_{13} (B @ 0.15% + Zn @ 0.2%)	70.82	148.87	6.93	16.33	4.33
T_{14} (B @ 0.15% + Zn @ 0.4%)	69.33	147.60	6.87	16.27	4.14
T_{15} (B @ 0.15% + Zn @ 0.6%)	76.59	157.80	7.20	16.87	5.07
Mean	74.82	155.25	7.15	16.72	4.81
F-test	**S**	**S**	**S**	**S**	**S**
S.Ed (±)	1.09	0.81	0.08	0.10	0.01
CD at 5 %	2.23	1.65	0.16	0.19	0.03

division and expansion in the different phases of growth reported by **Russel, (1957)**. Similar observations were reported by **Rajput *et al.,* (2003)** in African marigold.

Number of internodes per shoot: Maximum number of internodes per shoot was found from T_2 (17.27) followed by T_1 (17.07) whereas minimum number of internodes per shoot (16.07) were obtained in treatment T_0 (Control) at 120 days after planting. Variation in number of internodes per shoot might be due to optimal cellular maturation and cell division as it is one of the major functions of boron. Similar findings were recorded by **Kumar *et al.,* (2009)** in litchi and **Shukla, (2011)** in aonla.

Internodal length (cm): Longest internodal length was seen in T_2 (5.21 cm) followed by T_1 (5.17cm) whereas the shortest internodal length was obtained in treatment T_0 (3.96 cm) at 120 days after planting. This might have been due to favourable role of boron in N metabolism, cell division and expansion in the different phases of growth which is in line with the findings of **Russel (1957)** and **Rajput *et al.,* (2003)** in African marigold.

II. FLORAL AND QUALITATIVE PARAMETERS

Days taken to flower bud initiation after planting: There was a significant influence on earliness for flower bud initiation with the treatments. The earliest was recorded in T_6 (124.27 days) which followed by T_1 (125.40 days) while maximum days (141.87 days) were recorded in T_0 (control). Earliness in flower bud initiation might be due to zinc responsible for early maturity. It increases C: N ratio and thereby resulted in early bud initiation Similar results were reported by **Singh and Bhattacharjee, (1992)** in rose, **Halder *et al*., (2007)** in gladiolus, and **Kakade *et al*., (2009)** in china aster.

Days taken to bud opening: Significant difference was noted for days taken for bud opening from days taken to bud initiation. T_6 (14.47 days) recorded the earliest bud opening which is followed by T_1 (15.60 days) and T_0 (23.33 days.) had recorded maximum days. This variation might be due to zinc favors the storage of more carbohydrates through photosynthesis, which may be the attributing factor for the positive effect of zinc on early flowering. Similar results were reported by **Halder *et al*., (2007)** in gladiolus and **Ganga *et al*., (2009)** in Dendrobium.

Days taken to 50% flowering: T_6 obtained the minimum (138.73 days) number of days to 50 percent flowering from the days taken to bud opening which is followed by T_1 (141 days), while maximum days was recorded in treatment T_0 (165 days). Differences in days taken to 50 per cent flowering might be due to zinc favours the storage of more carbohydrates through photosynthesis, which may be the attributing factor for the positive effect of zinc on early flowering. Similar results in this respect were reported by **Halder *et al*., (2007)** in gladiolus and **Ganga *et al*., (2009)** in Dendrobium

Table 2.2 Effect of boron and zinc on various floral and qualitative parameters of carnation

Treatments	Days taken to flower bud initiation after planting	Days taken to bud opening	Days taken to 50% flowering	Bud length (tight-bud stage) (cm)	Bud diameter (cm)	Flower diameter (cm)	Flower stalk length (cm)	Flower stalk girth (mm)	Vase life (days)
T_0 (Control)	141.87	23.33	165.00	2.53	1.52	5.07	47.22	3.82	8.40
T_1 (B @ 0.05%)	125.40	15.60	141.00	3.05	1.87	6.05	53.66	4.71	10.60
T_2 (B @ 0.1%)	134.40	19.27	153.67	3.63	2.33	6.55	60.35	4.86	11.20
T_3 (B @ 0.15%)	137.53	19.47	157.00	3.37	2.05	6.37	57.41	4.77	10.73
T_4 (Zn @ 0.2%)	131.53	17.73	149.27	2.62	1.56	5.25	58.34	4.06	8.73
T_5 (Zn @ 0.4%)	127.27	16.73	144.00	2.67	1.62	6.55	66.23	4.17	9.07
T_6 (Zn @ 0.6%)	124.27	14.47	138.73	2.75	1.67	5.35	47.89	4.21	9.20
T_7 (B @ 0.05% + Zn @ 0.2%)	136.20	20.20	156.40	2.96	1.85	5.85	51.40	4.38	9.53
T_8 (B @ 0.05% + Zn @ 0.4%)	133.67	18.73	152.40	2.87	1.76	5.77	53.35	4.32	9.73
T_9 (B @ 0.05%+ Zn @ 0.6%)	126.53	16.20	142.73	2.83	1.72	5.61	55.43	4.27	9.33
T_{10} (B @ 0.1% + Zn @ 0.2%)	140.00	22.27	162.27	3.57	2.23	6.62	62.06	4.67	10.33
T_{11} (B @ 0.1% + Zn @ 0.4%)	134.33	19.47	153.80	3.53	2.17	6.59	56.97	4.61	10.60
T_{12} (B @ 0.1% + Zn @ 0.6%)	135.40	18.27	153.67	3.45	2.12	6.41	53.84	4.51	10.20
T_{13} (B @ 0.15% + Zn @ 0.2%)	138.53	19.73	158.27	3.26	2.02	6.26	59.07	4.57	10.07
T_{14} (B @ 0.15% + Zn @ 0.4%)	128.47	17.27	145.73	3.17	1.97	6.15	55.37	4.49	10.13
T_{15} (B @ 0.15% + Zn @ 0.6%)	132.40	18.27	150.67	3.11	1.93	6.05	51.72	4.41	9.80
Mean	132.99	18.56	151.55	3.09	1.90	6.03	55.65	4.43	9.85
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.Ed (±)	0.27	0.10	0.29	0.01	0.01	0.02	0.53	0.01	0.08
CD at 5 %	0.55	0.21	0.59	0.02	0.02	0.03	1.08	0.02	0.17

Bud length (tight-bud stage) (cm): The longest bud length was recorded in T_2 (3.63 cm). It was followed by T_{10} (3.57 cm) and the shortest bud length was recorded in T_0 (2.53 cm). This may be due to the positive effects of boron on reproductive stage of a plant as it increases the rate of translocation of sugars which are produced in the mature leaves into actively growing region **(Singh, 1996)** in calendula.

Bud diameter (cm): T_2 (2.33 cm) recorded significantly maximum bud diameter which is followed by T_{10} (2.23 cm) and the minimum bud diameter was recorded in treatment T_0 (1.52 cm). This may be a result of boron's favourable effects on a plant's reproductive stage, which include an increase in the rate at which sugars created in mature leaves are transported into areas of the plant that are actively growing. In calendula, **(Singh, 1996)** showed similar results.

Flower diameter (cm): The maximum diameter of the flower was recorded in T_{10} (6.62 cm) followed by T_{11} (6.59 cm) and T_0 recorded the lowest flower diameter of 5.07 cm. This may be due to the association of zinc in regulating semi permeability of cell walls. Similar findings are reported by **Singh and Bhattacharjee, (1992)** in rose, **Kumar and Arora, (2000)** in gladiolus and **Kumar *et al*., (2010)** in African marigold.

Flower stalk length (cm): There were significant differences among the treatments on the length of flower stalk. The longest flower stalk was found in T_5 (66.23 cm) followed by T_{10} (62.06 cm) while shortest length of flower stalk was obtained in T_0 (47.22 cm). The positive impact of zinc might be due to the ability of this nutrient in activating several enzymes catalase, peroxidase, tryptophan synthate and its involvement in chlorophyll synthesis and various physiological activities, ultimately leading to increase the stalk length of flower. Similar results were recorded by **Yadav *et al*., (2003)** in tuberose, **Sharma *et al*., (2004)** in gladiolus and **Jauhari *et al*., (2005)** in gladiolus.

Flower stalk girth (mm): Significant differences were noticed among the treatments with respect to girth of the flower stalk. T_2 recorded higher stalk girth (4.86 mm) which is followed by T_3 (4.77 mm) and T_0 (control) recorded the lowest stem girth of 3.82 mm. It may be due to the positive effects of boron on reproductive stage of a plant as it increases the rate of translocation of sugars which are produced in the mature leaves into actively growing regions and could have been further influenced by the growing environment **(Singh, 1996)** in calendula.

Vase life (days): The treatment T_2 differed significantly from all the other treatments in terms of vase life and recorded the longest vase life of 11.20 days which was closely followed by T_3 with 10.73 days and T_0 (control) recorded the minimum days of vase life of 8.40 days in distilled water. The flowers remained fresh for a longer period due to greater mobilization of assimilates towards the reproductive organs **(Singh, 1996)** in calendula.

III. Yield

Number of cut flowers stalks per plant per season: T_6 recorded significantly maximum number of flowers per plant (7.80) which is followed by T_9 (7.73) while minimum number of flowers per plant (5.20) was recorded in treatment T_0 (control). Zinc plays vital role in the production of vegetative growth; ultimately encourage the number of branches by involving in oxidation-reduction process, photosynthesis and breakdown of IAA, auxin and protein synthesis. Similar findings were reported by **Sharma *et al.*, (2004)** in gladiolus and **Jauhari *et al.*, (2005)** in gladiolus.

Number of flowers per meter square per season: Maximum number of flowers per meter square per season was significantly highest in T_6 (195.00) which followed by T_9 (193.33) while minimum flowers per meter square were recorded in T_0 (130.00). This might be due as zinc influences early maturity or due to the productive shoots produced and this might have led to increase in the flower yield. Similar findings were recorded by **Misra, (2001)** in chrysanthemum and **Nath and Biswas, (2002)** in tuberose.

Table 2.3 Effect of boron and zinc on yield parameters of carnation

Treatments	Number of cut flowers stalks per plant per season	Number of flowers per meter square per season
T_0 (Control)	5.20	130.00
T_1 (B @ 0.05%)	6.67	166.67
T_2 (B @ 0.1%)	6.73	168.33
T_3 (B @ 0.15%)	6.53	163.33
T_4 (Zn @ 0.2%)	6.33	158.33
T_5 (Zn @ 0.4%)	6.53	163.33
T_6 (Zn @ 0.6%)	7.13	178.33
T_7 (B @ 0.05% + Zn @ 0.2%)	6.60	165.00
T_8 (B @ 0.05% + Zn @ 0.4%)	6.80	170.00
T_9 (B @ 0.05%+ Zn @ 0.6%)	7.00	175.00
T_{10} (B @ 0.1% + Zn @ 0.2%)	6.33	158.33
T_{11} (B @ 0.1% + Zn @ 0.4%)	6.93	173.33
T_{12} (B @ 0.1% + Zn @ 0.6%)	6.67	166.67
T_{13} (B @ 0.15% + Zn @ 0.2%)	6.47	161.67
T_{14} (B @ 0.15% + Zn @ 0.4%)	6.47	161.67
T_{15} (B @ 0.15% + Zn @ 0.6%)	6.27	156.67
Mean	6.54	163.54
F-test	S	S
S.Ed (±)	0.10	2.56
CD at 5 %	0.21	5.24

4. CONCLUSION

Foliar application of 0.1 per cent boron at monthly intervals after planting resulted in significantly better plant height, number of leaves per plant, number of shoots per plant, number of internodes per shoot, internodal length, bud length, bud diameter, flower stalk girth and vase life. Foliar application of 0.6 percent zinc exhibited early days for days taken to bud initiation, days taken to bud opening, days taken to 50 percent flowering, number of cut flower stalks per plant and number of flowers per meter square while 0.4 percent zinc exhibited excellent flower stalk length and foliar application of 0.1 percent boron + 0.2 percent zinc produced good flower diameter. Thus, it is concluded that T_2 (B @ 0.1) and T_6 (Zn @ 0.6 %) are found suitable as they improve vegetative, flowering, quality, yield and economics parameters of carnation grown under naturally ventilated polyhouse conditions of Prayagraj.

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