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Effect of micro-nutrients on plant growth and flower yield of calendula (*Calendula officinalis* L.) cv. Doppiounder Prayagraj agro-climatic condition

Sanjay Singh, Deepanshu and Urfi Fatmi

Abstract
The present experiment was carried out during November, 2018 to February, 2019 in Departmental Research Field of Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design (RBD), with ten treatments of Micronutrients, the treatments were replicated thrice.The treatments were T_0 (Control), T_1 (Boron 0.2% + RDF), T_2 (Boron 0.4% + RDF), T_3 (Boron 0.6% + RDF), T_4 (Zinc 0.2% + RDF), T_5 (Zinc 0.4% + RDF), T_6 (Zinc 0.6% + RDF), T_7 (Iron 0.2% + RDF), T_8 (Iron 0.4% + RDF) and T_9 (Iron 0.6% + RDF). From the present investigation it is found that the treatment T_5(Zinc 0.4% + RDF) found best in terms of Plant Growth and Yield of Calendula followed by treatment T_4(Zinc 0.2% + RDF). In terms of economics of different treatments, maximum Gross Return, Net Return and Cost Benefit ratiowas found in T_5 (Zinc 0.4% + RDF)followed by treatment T_4 (Zinc 0.2% + RDF) where as minimum Plant growth and yield was recorded in treatment T_0(Control) but minimum cost benefit ratio was recorded in treatment T_0 (Control).

Keywords: Calendula, micronutrients, boron, zinc and iron

Introduction
Calendula *(Calendula officinalis)*, the pot marigold, ruddles, common marigold or Scotch marigold is a plant in the genus *Calendula* of the family Asteraceae. It is probably native to southern Europe, though its long history of cultivation makes its precise origin unknown, and it may possibly be of garden origin. It is also widely naturalized further north in Europe (north to southern England) and elsewhere in warm temperate regions of the world.

Calendula *(Calendula officinalis* L.) is an annual with bright yellow or orange daisy-like flowers. The flowers are harvested while in full bloom and dried for use as a medicinal or culinary herb. The entire flower heads or the petals alone are used. An Industrial oil may be expressed from the seeds and an absolute oilis obtained from the flowers. Laying chickens may be fedorange calendula flowers to give the egg yolks a deep yellow color. Calendula is a fast-growing annual that is easy to cultivate. Itmay be direct-seeded in the field and begins to flower in about two months. Harvest of calendula is time-consuming because the flowers form over a long period of time and individual flowers mature quickly. Over-mature flowers are undesirable in aherbal product. Frequent hand harvest is necessary to obtain the highest quality product, but some mechanization of harvest may be possible for a lower-grade product or for seed for industrial use.

Calendula is a winter season crop which is grown extensively in beds, baskets, and boxes. The word “calendula” has been derived from Latin word kalendae, meaning first day of the month. It gives a beautiful effect with red salvia, phlox and snapdragons and appeals the people who enjoy various colors (Kiritkar and Basu, 2000)

Calendula has long flowering period. Bearing large yellow or orange flowers with many petals, this herb is also grown as a common garden plant. Its stems and leaves are covered with hairs. This hardy annual prefers well drained, light and sandy soil and grows to a height of 21-65 cm.

It is a short-lived aromatic herbaceous perennial, growing to 80 cm (31 in) tall, with sparsely branched lax or erect stems. The leaves are oblong- lanceolate, 5–17 cm (2–7 in) long, hairy on both sides, and with margins entire or occasionally waved or weakly toothed. The inflorescences are yellow, comprising a thick capitulum or flower head 4–7 cm diameter surrounded by two rows of hairy bracts; in the wild plant they have a single ring of ray florets surrounding the central disc florets. The disc florets are tubular and hermaphrodite, and

generally of a more intense orange-yellow colour than the female, tridentate, peripheral ray florets. The flowers may appear all year long where conditions are suitable. The fruit is a thorny curved achene.

Calendula is used to treat a variety of skin diseases and is seen effective in treatment of skin ulcerations and eczema. Taken internally through tea, it is used for treatment of stomach ulcers. Calendula is effective in treating juvenile acne and dry psoriasis (Preethi and Kuttan, 2009) (Kindersley, 1996) and (Fonseca *et al.*, 2009)

*Calendula officinalis*is well adapted to temperate climatic zones in Europe, although it is believed to have originated in the Mediterranean. At present seed yields of 1000-1500 kg/hac are obtained on a farm scale, but with improved production system and selected varieties it is believed that yields could be double for making it an attractive industrial oil seed

Materials and Methods

The Experimental was conducted in Randomized Block Design (RBD) with 10treatments of Micronutrients with three replications in the Departmental Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during November, 2018 to February, 2019. Total number of treatments were ten*viz.*T_0 (Control), T_1 (Boron 0.2% + RDF), T_2 (Boron 0.4% + RDF), T_3 (Boron 0.6% + RDF), T_4 (Zinc 0.2% + RDF), T_5 (Zinc 0.4% + RDF), T_6 (Zinc 0.6% + RDF), T_7 (Iron 0.2% + RDF), T_8 (Iron 0.4% + RDF) and T_9 (Iron 0.6% + RDF).Cultivar Doppio were used for cultivation.

Climatic condition in the experimental site:

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ºC- 48 ºC and seldom falls as low as 4 ºC- 5 ºC. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion

The present investigation entitled **"**Effect of micro-nutrients on plant growth and flower yield of Calendula (*Calendula officinalis* L.) cv. Doppio under Prayagraj agro-climatic condition" was carried out during November 2018 to February, 2019 in Departmental Research Field of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The results of the present investigation, regarding the effect of micronutrients for Plant growth and yield of Calendula, have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Randomized block design with 10treatments, and three replications.

The results of the experiment are summarized below.

Growth Parameters

In terms of Plant Height, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (12.68, 23.20 and 34.42 cm) Plant height, at 30, 60 and 90 Days respectively in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (11.82, 22.39 and 32.68 cm) at 30, 60 and 90 days respectively, where as minimum plant height (8.85, 18.58 and 28.88 cm) was recorded in treatment T_0 (Control). The plant height significantly influenced with application of micronutrient, ZnSO4 it encourages, cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the plant height and is also improved root system of plants resulting in absorption of more water and nutrients and its utilization. Moreover, micronutrients activate several enzymes (catalase, carbonic dehydrogenize, tryptophan synthates etc.) and involved various physiological activities. Similar results were also obtained by Kakade *et al.* (2009) [7] in china aster, Balakrishnan (2005) [2] in marigold and Ahmad *et al.* (2010) [1] in Rose.

In terms of Plant Spread, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (14.39, 28.16 and 39.04 cm) Plant spread, at 30, 60 and 90 Days respectively in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (13.13, 26.04 and 37.11 cm) at 30, 60 and 90 days respectively, where as minimum plant spread (9.18, 22.15 and 31.27 cm) was recorded in treatment T_0 (Control). The plant sprayed significantly influenced with application of micronutrient, ZnSO4 it encourages, cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the plant spread and is also improved root system of plants resulting in absorption of more water and nutrients and its utilization. Moreover, micronutrients activate several enzymes (catalase, carbonic dehydrogenize, tryptophan synthates etc.) and involved various physiological activities. Similar results were also obtained by Kakade *et al.* (2009) [7] in china aster, Balakrishnan (2005) [2] in marigold and Ahmad *et al.* (2010) [1] in Rose.

In terms of Number of Leaves/Plant, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (19.27, 61.57 and 101.53) Number of leaves/Plant, at 30, 60 and 90 Days respectively in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (18.38, 55.87 and 97.18 leaves/plant) at 30, 60 and 90 days respectively, where as minimum Number of leaves/plant (15.50, 48.46 and 84.80) was recorded in treatment T_0 (Control). The result indicated that the foliar application of zinc might be stimulating metabolic activity with stimulating effect on cell wall loosing, increased cell elongation along with cell enlargement and cell differentiation resulting in increased photosynthesis and translocation of food material which might be enhanced the Number of leaves and leaves length. Similar results were also obtained by Bashir *et al*. (2013) [3] and Pal. *et al.* (2016) [12] in Gerbera.

In terms of Number of Branches, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (4.93, 19.00 and 28.65) Number of Branches/Plant, at 30, 60 and 90 Days respectively in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (4.57, 18.07 and 26.05 branches/plant) at 30, 60 and 90 days respectively, where as minimum Number of branches/plant (3.08, 14.29 and 20.47) was recorded in treatment T_0 (Control). Increased the number of Branches be due to micronutrients like ZnSO4 is essential component of several dehydrogenase, proteinase, peptidase and promotes growth of hormones and closely associated with growth, all these factors contributed to cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the number of Branches The above result was confirmed by Pal. *et al.* (2016) [12] in Gerbera.

In terms of Days required for first flower bud emergence, treatment T_5 (Zinc 0.4% + RDF) recorded minimum (36.97 days) for first flower bud emergence, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (38.20 days), where as maximum days taken for first flower bud emergence (47.01days) was recorded in treatment T_0 (Control).Micronutrients like zinc, favour to storage of more carbohydrates through photosynthesis, which may be enhanced to flower earlier. Similar results were also reported by Muthumanickam *et al.* (1999) [9], Senthamizhselvi (2000) [13] and Jadhav (2004) [6] in Gerbera.

In terms of Flower diameter, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (5.04 cm) flower diameter, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (4.89 cm), where as minimum flower diameter (4.02 cm) was recorded in treatment T_0 (Control).This might be due to more production of food material which subsequently increased in the quality parameters like flower stalk length, flower diameter. Similar results also reported by Muthumanickam *et al.* (1999) [9] in Gerbera, Nag and Biswas (2003) [10] and Hardeep Kumar *et al.* (2003) [5] in tuberose.

Yield Parameters:

In terms of Fresh weight of flowers, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (5.81 g) fresh weight of flower, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (5.56 g), where as minimum fresh weight of flower (4.75 g) was recorded in treatment T_0 (Control).The result might be due to the micronutrients such as zinc, it helps in regulating semi permeability of cell walls, thus mobilizing more water into flowers and also increase the synthesis of iron which promotes the flower size and weight of the flowers. Similar results were also reported by Nag and Biswas (2003) [10] and Hardeep Kumar *et al.* (2003) [5] in tuberose.

In terms of Number of flowers/plant, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (35.38) number of flowers/plant, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (34.03 flowers/plant), where as minimum number of flowers/plant (24.36) was recorded in treatment T_0 (Control).Application of zinc relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Similar results were also obtained by Nath and Biswas (2002) [11] in tuberose and pal *et al.* (2016) [12] in Gerbera.

In terms of Flower yield/plant, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (205.51 g) flower yield/plant, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (189.17 g), where as minimum flower yield/plant (115.76 g) was recorded in treatment T_0 (Control).

In terms of Flower yield/plot, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (3.28 kg) flower yield/plot, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (3.02 kg), where as minimum flower yield/plot (1.85 Kg) was recorded in treatment T_0 (Control). And Flower yield/ha, treatment T_5 (Zinc 0.4% + RDF) recorded maximum (19.35 tones) flower yield/ha, after transplanting in ten treatments of Boron, Zinc and Iron, followed by T_4 (Zinc 0.2% + RDF) with (17.82 tones), where as minimum flower yield/ha (10.92 tones) was recorded in treatment T_0 (Control). Application of zinc relieved the plants from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of the flower growth which may in turn increase the flower production and ultimately flower yield. Similar results were also obtained by Nath and Biswas (2002) [11] in tuberose and pal *et al.* (2016) [12] in Gerbera.

Economics of cultivation

Maximum Gross return, net returns and cost benefit ratio from flowers was found in the T_5Maximum gross returns (Rs. 774000.00), Net Return (Rs. 505680) and Cost Benefit Ratio (1:2.88) with application of (Zinc 0.4% + RDF) followed by T_4 (Zinc 0.2% + RDF) with Rs. 712800.00 gross return, Rs. 454980.00 net return and 1:2.76 cost benefit ratio where as minimum Gross return Rs. 436800.00, Net return Rs. 189480.00 and Cost benefit ratio 1:1.76 was recorded in treatment T_0 (Control.)

Table 1: Effect of Micronutrients onPlant height (cm), Plant spread (cm), Number of leaves/plant and Number of Branches/plantof Calendula (*Calendula officinalis*L.) cv. Doppio

Treatment Symbol	Treatment Combinations	Plant Height (cm)			Plant Spread(cm^2)			Number of Leaves /plant			Number of Branches/plant		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_0	Control	8.85	18.58	28.88	9.18	22.15	31.27	15.50	48.46	84.80	3.08	14.29	20.47
T_1	0.1% Boron+RDF	9.62	19.49	28.10	10.24	23.71	33.12	17.15	50.18	88.50	4.23	16.27	24.69
T_2	0.2% Boron+RDF	10.45	21.17	31.32	11.42	25.08	34.02	17.89	52.22	92.35	4.32	17.48	25.47
T_3	0.3% Boron+RDF	10.24	20.28	30.78	12.54	22.61	32.35	17.07	51.57	89.96	4.13	15.83	24.11
T_4	0.2% Zinc+RDF	11.82	22.39	32.68	13.13	26.04	37.11	18.38	55.87	97.18	4.57	18.07	26.05
T_5	0.4% Zinc+RDF	12.68	23.20	34.42	14.39	28.16	39.04	19.27	61.57	101.53	4.93	19.00	28.65
T_6	0.6% Zinc+RDF	11.19	21.08	31.27	12.86	25.15	35.29	18.08	54.72	95.24	4.39	17.72	25.30
T_7	0.2% Iron+RDF	10.21	18.92	30.05	11.71	23.93	34.16	16.45	52.00	93.70	4.12	16.21	22.19
T_8	0.4% Iron +RDF	10.68	19.92	31.12	12.16	24.98	35.22	18.06	54.47	95.58	4.34	17.59	24.75
T_9	0.6% Iron+RDF	10.17	19.01	29.07	11.43	23.12	33.06	17.09	50.56	90.05	4.10	16.32	23.55
F-test		S	S	S	S	S	S	S	S	S	S	S	S
SE(d)		0.136	0.236	0.411	0.201	0.436	0.329	0.217	0.536	0.525	0.059	0.151	0.443
C.V.		1.575	1.417	1.635	2.072	2.178	1.169	1.517	1.236	0.692	1.720	1.098	2.213
C.D. at 5%		0.288	0.500	0.870	0.426	0.922	0.697	0.459	1.136	1.111	0.125	0.320	0.938

Table 2: Effect of Micronutrients on Number of days required for first flower bud emergence, Flower diameter, Fresh weight of flower (g), Total Number of flowers/plant, Flower yield/plant, Flowers yield/plot, Flower Yield t/ha and Cost Benefit ratioof Calendula (*Calendula officinalis* L.) cv. Doppio

Treatment Symbol	Treatment Combinations	Number of days required for first flower bud emergence	Flower diameter (cm)	Fresh weight of flower (g)	Total Number of flowers/Plant	Flower yield/plant (g)	Flower yield/Plot (kg)	Flower yield/ha (tones)	Cost benefit ratio
T_0	Control	47.01	4.02	4.75	24.36	115.76	1.85	10.92	1:1.76
T_1	0.1% Boron+RDF	43.34	4.16	5.14	28.92	148.66	2.37	13.99	1:1.55
T_2	0.2% Boron+RDF	41.08	4.43	5.24	32.04	167.87	2.68	15.81	1:1.61
T_3	0.3% Boron+RDF	40.80	4.28	5.36	32.49	174.11	2.78	16.40	1:2.02
T_4	0.2% Zinc+RDF	38.20	4.89	5.56	34.03	189.17	3.02	17.82	1:2.04
T_5	0.4% Zinc+RDF	36.97	5.04	5.81	35.38	205.51	3.28	19.35	1:2.88
T_6	0.6% Zinc+RDF	39.65	4.77	5.23	31.82	166.43	2.66	15.69	1.2.76
T_7	0.2% Iron+RDF	42.38	4.40	5.12	29.93	153.22	2.44	14.40	1:1.45
T_8	0.4% Iron +RDF	42.30	4.53	5.39	32.31	174.20	2.78	16.40	1:1.48
T_9	0.6% Iron+RDF	41.17	4.61	5.48	33.57	183.93	2.94	17.35	1:2.10
F-test		S	S	S	S	S	S	S	
SE(d)		0.468	0.053	0.087	0.501	3.993	0.064	0.379	
C.V.		1.387	1.441	2.001	1.947	2.913	2.934	2.934	
C.D. at 5%		0.990	0.112	0.184	1.060	8.455	0.136	0.802	

Conclusion

Based on the present investigation it is concluded that the treatment T_5(Zinc 0.4% + RDF) found best in terms of Plant Growth and Yield of Calendula followed by treatment T_4(Zinc 0.2% + RDF). In terms of economics of different treatments, maximum Gross Return, Net Return and Cost Benefit ratiowas found in T_5 (Zinc 0.4% + RDF) followed by treatment $T_4$where as minimum Plant growth, yield and minimum cost benefit ratio was recorded in treatment T_0(Control).

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