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Effect of Foliar Spray of Micronutrients on Yield and Benefit-cost Ratio of Cauliflower (*Brassica oleracea* var. *botrytis* L.) under Polyhouse

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted during the *Kharif* season 2023 at the Center of Excellence on Protected Cultivation and Precision Farming, IGKV, Raipur, (C.G.). The experiment was laid in randomized block design (RBD) with three replications consisting of twelve treatments. The treatments included *viz.* T_0: Control, T_1: $FeSO_4$ (0.5%), T_2: $ZnSO_4$ (0.5%), T_3: Borax (0.2%), T_4: Ammonium Molybdate (0.03%), T_5: $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%), T_6: $FeSO_4$ (0.5%) + Borax (0.2%), T_7: $FeSO_4$ (0.5%) + Ammonium Molybdate (0.03%), T_8: $ZnSO_4$ (0.5%) + Borax (0.2%), T_9: $ZnSO_4$ (0.5%) + Ammonium Molybdate (0.03%), T_{10}: Borax (0.2%) + Ammonium Molybdate (0.03%) and T_{11}: $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) + Borax (0.2%) + Ammonium Molybdate (0.03%).

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Foliar spray of micronutrients was done at 30 and 45 DAT of cauliflower. The results revealed that foliar application of treatment T_{11} recorded significantly maximum yield parameters such as curd diameter (13.22 cm), curd depth (9.26 cm), curd size index (122.66 cm^2), total biomass production per plant (599.73 g), marketable curd weight (315.51 g), net curd weight (208.55g), yield per plot (6.94 kg plot^{-1}) and yield per hectare (231.37 qha^{-1}). In economics T_{11} incurred maximum total cost of cultivation (Rs. 263739.00 ha^{-1}), gross income (Rs. 809800.44 ha^{-1}), net income (Rs. 546061.44 ha^{-1}) and maximum benefit: cost ratio 3.07. In contrast, the minimum value for the above parameters were recorded under T_1 (control).

Keywords: Cauliflower; micronutrients; foliar spray; economics; benefit; cost ratio.

1. INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.), is an important Cole crop widely grown in tropics, subtropics and temperate regions of the world, which belongs to the family Brassicaceae and genus Brassica, has a chromosome number of 2n=18. Eastern Mediterranean region is its center of origin. The group 'Cole crop' is said to be derived from the wild cabbage, "Cole warts" (*Brassica oleracea* var. *sylvestris*). It is a fast-growing annual herbaceous vegetable crop with thick and small stems. Its main growing point develops into a short shoot system whose apices make up the convex surface of the curd, so the curd is a prefloral fleshy apical meristem that is used for making vegetables, curry, soup, and pickles [1]. Cauliflower is a thermo-sensitive crop. It can grow at an average temperature of 5-8°C to 25-28°C. During vegetative growth, some varieties may withstand temperature as low as -10°C and as high as 40°C for a few days. The optimum temperature for the growth of young plants is around 23°C and 17-20°C in later stages [2].

India is the second largest producer of cauliflower in the world. Area of cauliflower in India is 473 thousand ha. with a production of 92.83 lakh tonne and productivity 19.70 tonnes/ha. Cauliflower accounts for 5.06% of vegetable production in the country. The important cauliflower growing states are West Bengal, Madhya Pradesh, Bihar, Gujrat, Haryana, Orissa and Chhattisgarh. Chhattisgarh is the 7th highest producer of cauliflower in the India. In Chhattisgarh cauliflower is grown in 24.07 thousand ha area with production of 482.48 thousand tonnes and productivity is 20.04 tonnes/ha. The main cauliflower-growing districts are Kondagaon, Raipur, Durg, Surguja, Balod, Surajpur, Bemetara and Korba [3].

Micronutrients play an important role in the growth and development of plants. Though these are required in small amounts they are equally indispensable for the normal growth of the plant. However, in deficient conditions, they lead to the occurrence of some physiological disorders and ultimately affect the yield and quality of the cauliflower. Micronutrients improves curd's chemical composition and the plant's general condition. It increases macronutrient uptake, production, and quality through enhances photosynthetic activity and increases metabolite content of leaves. They also reduce the incidence of diseases, pests, and disorders and improve the post-harvest quality of the crop produced [4]. Objective of this research was to study the effect of foliar spray of micronutrients on yield and benefit-cost ratio of cauliflower.

2. MATERIALS AND METHODS

The experiment was conducted at the Center of Excellence on Protected Cultivation and Precision Farming, IGKV, Raipur, (C.G.) during *Kharif* season 2023. The experimental site comes sub-tropical conditions and was located at 21°14' N latitude and 81°41' E longitude with an altitude of 298.56 meters above the mean sea level. The experiment was laid out in randomized block design (RBD) with three replications consisting of twelve treatments. The cauliflower seedlings were transplanted at the spacing of 45x 30(R×P) cm. The size of each experimental field plot was taken 3 m^2. The soil type of the experimental field was clay loam in texture, nearly neutral in soil reaction (pH 7.21), organic carbon (0.38%), available N (176.08 kg/ha), P (14.42 kg/ha), K (380.54 kg/ha), Fe (19.80 mg/kg), Zn (0.81mg/kg), B (0.62 mg/kg) and Mo (0.15 mg/kg). During field preparation 10 tonnes/ha FYM and 10 quintal/ha vermicompost were added and water-soluble fertilizers such as 12:61:0, 0:52:34, 13:0:45, 19:19:19, and 00:00:50 were fertigated with the recommended dose of NPK (125:80:60 kg/ha). Foliar application of each treatment was done at 30 and 45 DAT.

Common cultural practices were done for cauliflower production such as irrigation, drenching, fertigation, weeding etc. For the preparation of solution of micronutrients, the required amounts of micronutrients were completely dissolved in the desired amount of water. Micronutrient solutions of different concentrations were carefully applied to both surfaces of the plant. Micronutrients were sprayed using a garden pump pressure sprayer, which was thoroughly cleaned before use to avoid contamination. Five randomly selected plants were tagged in each plot and used for recording observations of growth, yield and quality parameters.

3. RESULTS AND DISCUSSION

3.1 Yield Parameters

The result of various yield parameters *viz:* curd diameter, curd depth, curd size index, total biomass production per plant, marketable curd weight, net curd weight, yield per plot and yield per hectare as influenced by foliar spray of micronutrients on cauliflower are presented in Table 1 and Table 2. The effect of foliar spray of micronutrients exhibited significant differences with respect to all yield parameters. Results revealed that the foliar application of treatment T_{11} recorded a maximum curd diameter (13.22 cm) which was at par with T_6 (12.22 cm), T_7 (12.20 cm), T_8 (12.37 cm), T_9 (12.26 cm) and T_{10} (12.53 cm) while the minimum curd diameter (11.30 cm) was recorded in treatment T_0 (Control). Treatment T_{11} recorded a maximum curd depth (9.26 cm), which was at par with T_7 (8.58 cm), T_8 (8.67 cm), T_9 (8.60 cm) and T_{10} (8.82 cm), while the minimum curd depth (7.98 cm) was observed under the treatment T_0 (Control). Treatment T_{11} recorded a maximum curd size index (122.42 cm^2) which was at par with T_7 (104.68 cm^2), T_8 (107.25 cm^2), T_9 (105.44 cm^2) and T_{10} (110.52 cm^2), while the minimum curd size (90.39 cm^2) was observed under the treatment T_0 (Control). Treatment T_{11} recorded maximum total biomass production per plant (599.73 g), which was at par with T_6 (553.80 g**)**, T_7 (550.73 g), T_8 (563.73 g), T_9 (559.73 g) and T_{10} (580.60 g) whereas the minimum total biomass production per plant (517.60 g) was observed under the treatment T_0 (Control). Treatment T_{11} recorded a maximum marketable curd weight (315.51 g), which was at par with T_6 (294.63 g**)**, T_7 (293.93 g), T_8 (305.60 g), T_9 (302.93 g) and T_{10} (309.35 g) whereas the minimum marketable curd weight (280.93 g) was observed under the treatment T_0 (Control). Treatment T_{11} recorded a maximum net curd weight (208.55 g) which was at par with T_6 (189.44 g**)**, T_7 (188.78 g), T_8 (193.78 g), T_9 (191.34 g) and T_{10} (194.67 g) whereas the minimum net curd weight (176.83 g) was observed under the treatment T_0 (Control). Treatment T_{11} recorded a maximum yield per plot (6.94 kg), which was at par with T_6 (6.48 kg**)**, T_7 (6.47 kg), T_8 (6.72 kg), T_9 (6.66 kg) and T_{10} (6.81 kg) whereas the minimum yield per plot (6.18 kg) was observed under the treatment T_0 (Control). Treatment T_{11} recorded maximum yield per hectare (231.37 qha^{-1}) which was at par with T_6 (216.06 qha^{-1}**)**, T_7 (215.55 qha^{-1}), T_8 (224.11 qha^{-1}), T_9 (222.15 qha^{-1}) and T_{10} (226.86 qha^{-1}) whereas the minimum yield per hectare (206.02 qha^{-1}) was observed under the treatment T_0 (Control).

Combine micronutrients enhance the curd diameter, curd depth and curd size index due to the promote physiological activities like photosynthesis, translocation of assimilates from leaves to curd and storage of assimilates in curd for which boron and zinc may be responsible factor as reported by Lashkari et al*.* [5]. Iron play major role in formation of chlorophyll which is the major component of photosynthesis. molybdenum involves in various enzymes that regulates the nitrogen metabolism in plants. Similar results have been reported by Kotur [6] Mori et al. [7] Punam et al. [8] Kumar et al. [9] and Moklikar et al*.* [10]

The contribution of foliar application of different micronutrient mixture to increase in total biomass production per plant, marketable curd weight, net curd weight, yield per plot and yield per hectare is might be due to availability of essential micro-nutrients at the required growth stages, which increases the rate and efficiency of metabolic activities resulting in high assimilation of proteins and carbohydrates which translocated to curd and helped in enhancing the biomass and yield of cauliflower. Iron is essential for chlorophyll synthesis, which is crucial for photosynthesis, zinc acts as a catalyst for the synthesis of enzyme tryptophane synthetase involved in the biosynthesis of auxin, which regulates the growth and development of cauliflower, boron is crucial for cell wall formation and transport of sugars, molybdenum acts as a cofactor for the enzyme (nitrate reductase) involved in nitrogen metabolism. Similar results have been reported by Moklikar et al*.* [10] Bairwa et al*.* [11] Chaudhari et al*.* [12] Ali et al*.* [13] and Kumar et al*.* [14].

Table 1. Effect of foliar spray of micronutrients on curd diameter (cm), curd depth (cm), curd size index (cm^2), total biomass production per plant (g), marketable curd weight (g) and net curd weight (g)

Tr. No.	Treatments details	Curd diameter (cm)	Curd depth (cm)	Curd size index (cm^2)	Total biomass production per plant (g)	Marketable curd weight (g)	Net curd weight (g)
T_0	Control	11.30	7.98	90.39	517.60	280.93	176.83
T_1	$FeSO_4$ (0.5%)	11.71	8.18	95.84	513.27	281.33	179.62
T_2	$ZnSO_4$ (0.5%)	11.72	8.21	96.21	521.93	281.54	180.36
T_3	Borax (0.2%)	11.80	8.25	97.31	526.80	284.25	186.22
T_4	Ammonium Molybdate (0.03%)	11.80	8.22	97.06	525.73	283.07	185.96
T_5	$FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%)	12.16	8.28	100.71	542.80	287.53	188.44
T_6	$FeSO_4$ (0.5%) + Borax (0.2%)	12.22	8.40	102.65	553.80	294.63	189.44
T_7	$FeSO_4$ (0.5%) + Ammonium Molybdate (0.03%)	12.20	8.58	104.68	550.73	293.93	188.78
T_8	$ZnSO_4$ (0.5%) + Borax (0.2%)	12.37	8.67	107.25	563.73	305.60	193.78
T_9	$ZnSO_4$ (0.5%) + Ammonium Molybdate (0.03%)	12.26	8.60	105.44	559.73	302.93	191.34
T_{10}	Borax (0.2%) + Ammonium Molybdate (0.03%)	12.53	8.82	110.52	580.60	309.35	194.67
T_{11}	$FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) + Borax (0.2%) + Ammonium Molybdate (0.03%)	13.22	9.26	122.42	599.73	315.51	208.55
	SE (m)	0.35	0.24	4.68	16.99	8.67	5.51
	C.D. (5% level)	1.03	0.72	18.31	49.83	25.45	20.05
	C.V.	5.05	5.05	7.95	5.38	5.12	5.06

Recommended dose of Nitrogen, Phosphorus and Potash (125:80:60 kg/ha) were applied in all the treatments, $FeSO_4$ - Iron Sulphate, $ZnSO_4$ - Zinc Sulphate, g- gram, cm- centimeters, SE (m)- Standard error of the mean, C.D.- Critical difference, C.V.- Coefficient of variation

Table 2. Effect of foliar spray of micronutrients on yield per plot (kg plot^{-1}), yield per hectare (qha^{-1}), cost of micronutrients (Rs. ha^{-1}), total cost of cultivation (Rs.ha^{-1}), gross income (Rs. ha^{-1}), net income (Rs. ha^{-1}) and B:C ratio

Tr. No.	Treatments details	Yield per plot (kg plot^{-1})	Yield per hectare (qha^{-1})	Cost of micronutrients (Rs. ha^{-1})	Total cost of cultivation (Rs.ha^{-1})	Gross income (Rs.ha^{-1})	Net income (Rs.ha^{-1})	B:C ratio
T_0	Control	6.18	206.02	0.00	258324.00	721062.22	462738.22	2.79
T_1	$FeSO_4$ (0.5%)	6.19	206.31	495.00	258819.00	722088.89	463269.89	2.79
T_2	$ZnSO_4$ (0.5%)	6.19	206.46	900.00	259224.00	722619.33	463395.33	2.79
T_3	Borax (0.2%)	6.25	208.45	510.00	258834.00	729578.42	470744.42	2.82
T_4	Ammonium Molybdate (0.03%)	6.23	207.58	3510.00	261834.00	726537.78	464703.78	2.77
T_5	$FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%)	6.33	210.86	1395.00	259719.00	738002.22	478283.22	2.84
T_6	$FeSO_4$ (0.5%) + Borax (0.2%)	6.48	216.06	1005.00	259329.00	756217.00	496888.00	2.92
T_7	$FeSO_4$ (0.5%) + Ammonium Molybdate (0.03%)	6.47	215.55	4005.00	262329.00	754428.89	492099.89	2.88
T_8	$ZnSO_4$ (0.5%) + Borax (0.2%)	6.72	224.11	1410.00	259734.00	784373.33	524639.33	3.02
T_9	$ZnSO_4$ (0.5%) + Ammonium Molybdate (0.03%)	6.66	222.15	4410.00	262734.00	777528.89	514794.89	2.96
T_{10}	Borax (0.2%) + Ammonium Molybdate (0.03%)	6.81	226.86	4020.00	262344.00	794002.61	531658.61	3.03
T_{11}	$FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) + Borax (0.2%) + Ammonium Molybdate (0.03%)	6.94	231.37	5415.00	263739.00	809800.44	546061.44	3.07
	SE (m)	0.19	6.36					
	C.D. (5% level)	0.56	18.66					
	C.V.	5.12	5.12					

Recommended dose of Nitrogen, Phosphorus and Potash (125:80:60 kg/ha) were applied in all the treatments, $FeSO_4$ - Iron Sulphate, $ZnSO_4$ - Zinc Sulphate, kg plot^{-1} – Kilogram per plot, qha^{-1} – Quintal per hectare, Rs. Ha^{-1} - Rupees per hectare, B:C ratio – Benefit-cost ratio, SE (m)- Standard error of the mean, C.D.- Critical difference, C.V.- Coefficient of variation

3.2 Benefit-Cost Ratio

The effect of foliar spray of micronutrients on the economics of cauliflower are presented in Table 2. The highest total cost of cultivation (Rs. 263739.00 ha^{-1}) was incurred under treatment T_{11}, followed by (Rs. 262734.00 ha^{-1}) in treatment T_9 and the lowest total cost of cultivation Rs. 258324.00 ha^{-1} incurred in treatment T_0 (control). The highest gross income of Rs. 809800.44 ha^{-1} was obtained under treatment T_{11}, followed by (Rs. 794002.61 ha^{-1}) in treatment T_{10} and the lowest gross income Rs. 721062.22 ha^{-1} was obtained in treatment T_0 (control). The highest gross income of Rs. 809800.44 ha^{-1} was obtained under treatment T_{11}, followed by (Rs. 794002.61 ha^{-1}) in treatment T_{10} and the lowest gross income Rs. 721062.22 ha^{-1} was obtained in treatment T_0 (control). The maximum net income of Rs. 546061.44 ha^{-1} was obtained under treatment T_{11}, followed by (Rs. 531658.61 ha^{-1}) in the treatment T_{10} and the lowest net income Rs. 462738.22ha^{-1} was obtained in treatment T_0 (control). The highest benefit: cost ratio of 3.07 was obtained under treatment T_{11}, followed by 3.03 in treatment T_{10} and the lowest benefit: cost ratio of 2.79 was obtained in treatment T_0 (control). Similar results were reported by Moklikar et al. [10] and Punam et al. [8].

4. CONCLUSION

Based on the results obtained from the present investigation it can be concluded that a foliar application of treatment T_{11}: FeSO4 (0.5%) + $ZnSO_4$ (0.5%) + Borax (0.2%) + Ammonium Molybdate (0.03%) at 30 and 45 days after transplanting significantly enhanced the yield parameters and also recorded highest B:C ratio with net income of Rs. 546061.44 ha^{-1}. Hence, the treatment T_{11} can be considered the most effective and beneficial for cauliflower production compared to all other treatments and can be recommended for production practices to the farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I (Ashok Tirkey) have hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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