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Punam
Department of Vegetable science, College of Agriculture, Indira Gandhi Krishi, Vishwavidyalaya, Raipur, Chhattisgarh, India

Dr. Rajshree Gayen
Department of Vegetable science, College of Agriculture, Indira Gandhi Krishi, Vishwavidyalaya, Raipur, Chhattisgarh, India

Dr. PK Sharma
Department of Vegetable science, College of Agriculture, Indira Gandhi Krishi, Vishwavidyalaya, Raipur, Chhattisgarh, India

Dr. HK Panigrahi
Department of Vegetable science, College of Agriculture, Indira Gandhi Krishi, Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Punam
Department of Vegetable science, College of Agriculture, Indira Gandhi Krishi, Vishwavidyalaya, Raipur, Chhattisgarh, India

Effect of foliar feeding of micronutrients on growth and yield of cauliflower (*Brassica oleraceae var. botrytis* L.) cv. Ragini under net tunnel

Punam, Dr. Rajshree Gayen, Dr. PK Sharma and Dr. HK Panigrahi

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Abstract
The present experiment was conducted at Centre of Excellence on Protected cultivation & Precision Farming at Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh under net tunnel with eight treatment and three replications in Randomized Block Design (RBD) the treatment consisted four different micronutrient (B, Mo, Zn, S) and its combination with different concentrations and recommended dose of fertilizer *viz.* T_0: RDF + Control (water spray), T_1: RDF+ Boric acid (H_3BO_3) @0.2%, T_2: RDF+ Ammonium molybdate ($(NH_4)_2MoO_4$) @0.1%, T_3: RDF+ $ZnSO_4$@0.5%, T_4: RDF+ $MnSO_4$@0.5%, T_5: RDF+ Boric acid @0.2%+Ammonium molybdate ($(NH_4)_2MoO_4$) @0.1%, T_6 : RDF +Boric acid(H_3BO_3) @ 0.2% + Ammonium molybdate ($(NH_4)_2MoO_4$) @ 0.1%+ ZnSO4 @ 0.5% and T_7: RDF + Boric acid (H_3BO_3) @0.2%+ Ammonium molybdate ($(NH_4)_2MoO_4$) @ 0.1% + $ZnSO_4$@ 0.5% + $MnSO_4$ @0.5%. Data were analyzed to work out the growth and yield parameters. Result revealed that T_7: RDF +Boric acid @ 0.2%+ Ammonium molybdate@ 0.1%+Zinc sulphate @ 0.5%+ Manganese sulphate @ 0.5% was exhibited early initiation and maturity of curd. Highest curd yield 34.98 t/ha was produced in T_7: RDF +Boric acid @ 0.2%+ Ammonium molybdate@ 0.1% + Manganese sulphate@ 0.5%+Zinc sulphate@ 0.5% followed by T_6: RDF + Ammonium molybdate@ 0.1%+ Boric acid @ 0.2% + Zinc sulphate@ 0.5% which was 33.97 t/h.

Keywords: Ragini, *Brassica oleraceae*, Indira Gandhi Krishi Vishwavidyalaya

Introduction
Cole group of vegetables are important among all winter vegetable. Cauliflower (*Brassica oleracea var. botrytis* L.) belongs to family Brassicaceae and it is one of the most important cool vegetables of cole group cultivated in India. Cole crops are rich in antioxidants, and glucosinolates and having anti-inflammatory properties. These vegetables are excellent source of fiber, aiding in food passage, digestion, healing stomach ulcers, and cardio-vascular health.
Nutritionally the 100 g edible portion of cauliflower has high quality protein (2.6 g), moisture (90.8 g), fat (0.4 g), carbohydrates (4.0g), calcium (33.0 mg), phosphorus (P) (57.0 mg), iron (1.5 mg), carotene (30.0 mg), thiamine (0.04 mg), riboflavin (0.1 mg), vitamin C (56.0 mg) and energy (30 kcal) (Singh, 1998).
India is the largest producer of cauliflower in the world (Thamburaj and Singh, 2001). In India area under cauliflower is 454.0 thousand hectares with production of 8557 thousand metric tonnes and productivity is 18.85 tonnes/ha. (Anon, 2017) [1]. Area under cauliflower in Chhattisgarh is 23.95 thousand hectare with production of 453.19 thousand metric tones and productivity is 18.92 mt/ha (Anon, 2017) [2].
The crop grown in open fields is often exposed to fluctuating temperature, humidity, unexpected heavy rains and insect pest diseases which ultimately affect the crop productivity adversely. Hence, to obtain a good quality produce, there is a need to cultivate cauliflower under protected condition such as green houses, net tunnels or polyhouses. Very few attempts have been made to work out the optimum fertilizer schedules for cauliflower under protected cultivation. It is well established fact that macro nutrients such as boron, zinc molybdenum sulphur and nitrogen have profound effect on crop productivity and quality.

Micronutrient plays a important role in growth and development of plant. Though these are required in small amount but equally indispensable for the normal growth of the plant and in deficient condition these lead to the occurrence of some physiological disorders and ultimately affect the yield and quality of the cauliflower. Micronutrient improves the chemical composition of curd and general condition of the plant. It increases seed germination, macronutrient uptake, production and quality through enhanced photosynthetic activity and increased metabolite content of leaves. They also reduce the incidence of diseases, pests and disorders and improve the postharvest quality of the crop produce. (Hemphill *et al*., 1982).

Different micronutrients have specific role in cauliflower production. Among all (Boron, Molybdenum, Iron, Copper, Chlorine, Zinc and Manganese), Boron and Molybdenum are more important than others due to its availability in soil, mobility in plants and soil and more dependency upon pH in soil. (Chaudhari *et al.*, 2017) [3]. Keeping these points in mind the present experiment has been framed.

Materials and Methods

The experiment was carried out during the year 2018 at Centre of Excellence on Protected Cultivation and Precision Farming under net tunnel, College of Agriculture, IGKV, Raipur (C.G.). Ragini cultivar was selected for the experiment as it showed very good performance in climate of Chhattisgarh. The experiment was comprises of 8 treatments viz: T_0 - RDF + Control (water spray); T_1 - RDF+ Boric acid(B) @0.2%; T_2 - RDF+ Ammonium molybdate (Mo) @0.1%; T_3 - RDF+ Zinc sulphate (Zn) @0.5%; T_4 - RDF+ Manganese sulphate (S) @0.5%; T_5 - RDF+ Boric acid (B) @0.2% + Ammonium molybdate (Mo) @0.1%; T_6 - RDF +Boric acid (B)@0.2% + Ammonium molybdate (Mo) @0.1%+ Zinc sulphate (Zn) @ 0.5% ; T_7 - RDF +Boric acid (B)@0.2%+ Ammonium molybdate (Mo)@0.1%+Zinc sulphate (Zn) @0.5%+ Manganese sulphate (S) @0.5% and laid out in Randomized Block Design under 3 replications. Spacing between plant to plant and row to row was maintained at 45x60cm.

The soil type of experimental field was clay-loam. At the time of field preparation, FYM 25 tones/ha was added in the soil. During crop periods, the water soluble fertilizers i.e. 13:00:45, 12:61:00, 17:44:00, 18:18:18, 19:19:19, and 00:00:50 were applied through fertigation to meet out the fertilizer requirement of the crops.

For preparation of micro-nutrients solution the desired amounts of micro-nutrients were dissolved thoroughly with desired amount of water and surfactant is added as a spreader and sticker. Solutions of various concentrations were spread carefully to wet both the surfaces of the plant. Uniform spray of solution to all the plants was done. The solution, which is fell from leaves, was collected on polythene, which were spread on the ground. Avoided the inclusion of micronutrient to the soil this precaution was taken. Spraying of micro-nutrients was done with the help of knap sack sprayer and to avoid contamination sprayer was washed thoroughly before spraying.

Plants with 3-4 leaf were transplanted on raised beds of the size 2.0 × 1.0 m. The desired concentrations of micro-nutrients were prepared and sprayed at the time of 30, 45, 60 days after the transplanting of cauliflower crops**.** Observations were recorded on plant height, number of leaves per plant, days to curd initiation, days to 50% curd maturity, curd diameter, curd depth, curd yield.

Results and Discussion

Table 1: Growth and yield parameters as influenced by foliar feeding of micro-nutrients on cauliflower cv. Ragini under net tunnel.

Notations	Treatments	Plant height (cm)	No. of leaves/ plant	Curd diameter (cm)	Curd depth	Days to first curd initiation
T_0	RDF + Control (water spray)	65.32	18.66	37.62	8.04	47.33
T_1	RDF+ Boric acid(B) @0.2%	72.72	21.00	39.02	8.77	46.33
T_2	RDF+ Ammonium molybdate (Mo) @0.1%	73.33	22.13	39.04	8.82	46.33
T_3	RDF+ Zinc sulphate (Zn) @0.5%	73.48	22.80	38.45	8.74	47.06
T_4	RDF+ Manganese sulphate (S) @0.5%	73.40	23.26	38.94	8.78	46.53
T_5	RDF+ Boric acid (B) @0.2% + Ammonium molybdate (Mo) @0.1%	74.00	24.33	40.56	9.24	46.73
T_6	RDF +Boric acid (B)@0.2% + Ammonium molybdate (Mo) @0.1%+ Zinc sulphate (Zn) @ 0.5%	74.15	25.26	40.92	9.43	45.40
T_7	RDF +Boric acid (B)@0.2%+ Ammonium molybdate (Mo)@0.1%+Zinc sulphate (Zn) @0.5%+ Manganese sulphate (S) @0.5%	76.78	25.60	41.22	9.54	44.06
	Mean	72.90	22.88	39.08	8.68	46.35
	SEm±	0.58	0.25	0.21	0.70	0.59
	CD(p=0.05)	1.76	0.78	0.66	0.24	1.79
	CV	1.38	1.94	0.96	1.58	2.21

Table 2: Growth and yield parameters as influenced by foliar feeding of micro-nutrients on cauliflower cv. Ragini under net tunnel condition.

Notations	Treatments	days to 50 % curd maturity	Gross curd weight (kg)	Net curd weight (kg)	Yield (t/ha)
T_0	RDF + Control (water spray)	58.00	1.29	0.38	22.24
T_1	RDF+ Boric acid(B) @0.2%	57.66	1.68	0.50	27.54
T_2	RDF+ Ammonium molybdate (Mo) @0.1%	57.66	1.68	0.48	25.75
T_3	RDF+ Zinc sulphate (Zn) @0.5%	57.20	1.60	0.56	26.75
T_4	RDF+ Manganese sulphate (S) @0.5%	57.33	1.73	0.44	26.59
T_5	RDF+ Boric acid (B) @0.2% + Ammonium molybdate (Mo) @0.1%	57.66	1.77	0.55	32.52
T_6	RDF +Boric acid (B)@0.2% + Ammonium molybdate (Mo) @0.1%+ Zinc sulphate (Zn) @ 0.5%	57.00	1.80	0.60	33.97
T_7	RDF +Boric acid (B)@0.2%+ Ammonium molybdate (Mo)@0.1%+Zinc	56.66	1.84	0.65	34.98

	sulphate (Zn) @0.5%+ Manganese sulphate (S) @0.5%				
	Mean	57.20	1.63	0.51	28.79
	SEm±	0.38	0.02	0.01	0.19
	CD(p=0.05)	1.17	0.08	0.05	0.59
	CV	1.17	2.95	6.24	1.17

Effect of application of the micro-nutrients exhibited significant difference with respect to plant height recorded at 60 days after transplanting (DAT) i e at harvest are presented in Table 1. The highest plant height (76.78 cm) was reported under the T_7 {RDF +Boric acid (H_3BO_3) @ 0.2%+ Ammonium molybdate @ 0.1%+ $MnSO_4$ @ 0.5%+ $ZnSO_4$ @ 0.5%} followed by T_6 (74.15 cm). All the treatments of micronutrients significantly increase the plant height over control.

Application of different micronutrients might have accelerated the rate of metabolic activities in the plant system that might have resulted in increasing height of the plant. Boron is very important for growth and development of cauliflower and is involved in cell division and hence helps in root elongation. It is associated with several physiological processes such as calcium metabolism, auxin synthesis. Similar result was also observed by Singh *et al*. (2017) [13] and Sitapara *et al.* (2011) [14] in cauliflower.

At 60 DAT the maximum number of leaves per plant (25.60) was noted in treatment T_7 {RDF +Boric acid @ 0.2%+ Ammonium molybdate @ 0.1%+Zinc sulphate @ 0.5%+ Manganese sulphate @0.5%} followed by T_6 (25.26), T_5 (24.33), and T_4 (23.26),while minimum (18.66) under the treatment T_0 (RDF + Control).

This could be the result of availability of required quantity of essential plant nutrients at various growth stages leading to hastening the metabolic processes of plant and sugar metabolism, translocation of solutes and protein synthesis that might have resulted in production of more number of leaves, similar result was also reported by Chaudhari *et al*, 2017 [3] in cauliflower.

Significant differences were observed among the treatments in respect to curd diameter. The maximum curd diameter observed (41.22cm) under the treatment T_7 {RDF +Boric acid @ 0.2%+ Ammonium molybdate @ 0.1% + $ZnSO_4$ @ 0.5% + $MnSO_4$ @ 0.5%} followed by T_6 (40.92cm), T_5 (39.20cm), T_4 (38.94cm).

Combine micronutrients enhance the curd width and curd weight due to the improvement in physiological activities like photosynthesis, translocation of assimilates from leaves to curd and their storage in curd for which zinc may be a responsible factor as reported by Lashkari *et al.* (2008) [7].

Significant differences were observed among the treatments in respect to curd depth. The maximum curd depth observed (9.54cm) under the treatmentT_7 {RDF +Boric acid @ 0.2%+ Ammonium molybdate @ 0.1%+Zinc sulphate @ 0.5%+ Manganese sulphate @0.5%} followed by T_6(9.43cm), T_5 (8.78cm) and the minimum curd depth (8.04cm) was observed under the treatment T_0 (RDF + Control).

The formation of bigger curd with the application of higher levels of micronutrients might be due to higher synthesis of carbohydrate and their translocation to the curd, which subsequently helped in the formation of bigger curd of cauliflower. Similar results have been reported by Kotur 1998 [6], Prasad and Yadav 2003 [9].

As per the data is concerned the maximum days to curd initiation (47.33days) was observed under treatment T_0 (RDF + Control) while, the minimum days to curd initiation (44.06days) was found in treatment T_7 {RDF + Boric acid @0.2% + Ammonium molybdate @ 0.1% + Zinc sulphate @ 0.5% + Manganese sulphate @0.5%} followed by T_6 (45.40days), T_5 (46.53days).

It was observed that the curd initiation period required in plants decreased with the increasing levels of micronutrients application.; This might be due to the positive role played by the regulating micronutrients in the balanced absorption of nutrients might improve physiological activities, which resulted in the endogenous growth hormone synthesis responsible for early curd formation in plants. The present result is in agreement with the findings of Verma, 2009 [15] in cauliflower.

Treatment T_7 {RDF + Boric acid @ 0.2%+ Ammonium molybdate @ 0.1%+Zinc sulphate @ 0.5%+ Manganese sulphate @0.5%}has taken 56.66 days with the shortest period of curd maturity and followed by T_6 (57days), T_5 (57.66 days) whereas, the maximum days to 50% curd maturity (58.00days) was observed in treatment T_0 (RDF + Control).

The enhancement in growth parameters might be due to the function of boron, which further causes the precipitation of higher cation, action of buffer, maintenance of conducting tissues, which helps in promoting the absorption of nitrogen. However, micronutrients activates physiological process by stimulating the metabolism and enhance growth of the plant. Which might have been resulted in increase in gross weight of curd. The finding is in accordance with the study carried out by the Ghosh & Hasan (1997) [4] and Maurya *et al.* (1992) [8] in cauliflower.

Gross curd weight is cumulative contribution of plant frame, number of leaves as well as net curd weight. Gross curd weight ranged between 1.84 kg to 1.29kg. The highest gross curd weight (1.84 kg) was recorded in treatment T_7 {RDF +Boric acid @ 0.2%+ Ammonium molybdate @ 0.1%+Zinc sulphate @ 0.5%+ Manganese sulphate @ 0.5 %} followed by T_6 (1.80kg), T_5 (1.77kg), T_4 (1.73kg).Whereas the lowest gross curd weight (1.29kg) was recorded in treatment control (T_0). The general mean was 1.63kg.

Net curd weight is the ultimate produce which is valued in the market as well as by consumers. Net curd weight ranged between 0.65kg to 0.38kg. The data indicated that maximum Net curd weight was observed (0.65kg) under the treatment T_7 {RDF + Boric acid @ 0.2% + Ammonium molybdate @ 0.1% + Zinc sulphate @ 0.5%+ Manganese sulphate @0.5%} followed by T_6 (0.60kg), T_5 (0.55kg), T_4 (0.44kg) and the minimum net curd weight (0.38kg)) was reported under the treatment T_0 (RDF + Control).

The increase in the weight of curd might be due to physiological role of zinc and boron and other combined micronutrients. The favorable effects of zinc can be attributed to the fact that, the element is essential in nitrogen metabolism and it also increases the synthesis of auxin which promotes the cell size. Moreover, zinc acts as a catalyst in the oxidation and reduction process and has importance in sugar metabolism, which might have increased curd weight. The present findings are in conformity with the reports of Kanujia *et al.* 2006 [5].

The highest yield (34.98 t/ha) was reported under the treatment T_7 {RDF+ Boric acid (H_3BO_3) @ 0.2%+

Ammonium molybdate @ 0.1%+ $ZnSO_4$ @ 0.5%+ $MnSO_4$ @ 0.5%} followed by T_6 (33.97t/ha) (RDF +Boric acid @ 0.2% + Ammonium molybdate @ 0.1%+ $ZnSO_4$ at the rate 0.5%), T_5 (RDF+ Boric acid (H_3BO_3) @ 0.2% + Ammonium molybdate @ 0.1%) and the minimum yield (22.24t/ha) was recorded under the treatment T_0(RDF + Control).

Improvement in the yield might be due to the combined spraying of different micronutrients at required levels which might have high uptake of major nutrients and resulted in sturdy plant growth, which enhance yield and quality. Present result is in agreement with the findings of Singh (2003) [12].

Promotive effects of molybdenum on vegetative growth enhanced curd yield which ultimately leads to more photosynthesis activities while, application of boron, enhanced carbohydrates, nitrogen metabolism of the pectic substances, as well as enhance the water metabolism and water relation in plants. These findings corroborate with the results reported by Rahman *et al*. 1992 [10] and Sharma 2002 [11].

It can be concluded based on the results obtained from the present investigation that application of different micronutrients (T_7) and its combination along with recommended dose of fertilizer was found effective for cauliflower production.

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