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Response of Cauliflower (*Brassica oleracea var. Botrytis*) to Micronutrient Mixture in the Micronutrient Deficient *Alfisol*

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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

Aim: Though the effect of foliar application of micronutrients is well established, research on the performance of cauliflower with combined application of micronutrients is very meager. Keeping this in view, the research work was proposed to assess the effect of Micronutrient Mixture on the growth, yield, and quality of cauliflower under field conditions.
Study Design: The field experiment in a randomized block design consisted of 6 treatment combinations with four replications.
Place and Duration of Study: The experiment was conducted at Farmers Field, Deverayapuram, Thondamuthur, Coimbatore. The field experiment was conducted from March 2023 to May 2023.

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Methodology: The micronutrient mixture specific to cauliflower was developed at various levels based on their requirement to crop, with data obtained from soil testing, literature on nutrient uptake, and micronutrient deficiencies in cauliflower crops. Different rates of micronutrient mixture *viz.,* 15, 20, 25, and 30 kg ha^{-1} combined with farmyard manure (FYM), were used to enhance fertilizer solubility.

Results: It was recorded that the application of Micronutrient Mixture @ 30 kg ha^{-1} increased morphological characters and yield compared to other treatments followed by the Micronutrient Mixture @ 25 kg ha^{-1}. The minimum yield and morphological characters were recorded in the control plot where neither FYM nor Micronutrient Mixture was applied.

Conclusion: This research depicted that the combined application of a micronutrient mixture @ 30 kg ha^{-1} incubated with FYM has a positive impact on the growth, yield, and quality of cauliflower in micronutrient-deficient soil under field conditions resulting in improved morphological characters and crop yield. Hence, it may be concluded that an optimum dose of 30kg ha^{-1} can be recommended for cauliflower in micronutrient-deficient soils to enhance crop productivity.

Keywords: Micronutrient mixture; cauliflower; growth parameters.

1. INTRODUCTION

The Green Revolution, which took place from the 1940s to the 1960s, witness a series of agricultural advancements aimed at increasing crop yields worldwide. It primarily focused on the development and widespread adoption of high-yielding crop varieties, increased use of synthetic fertilizers, pesticides, and improved irrigation methods. Their main focus was on important crops with the application of N alone to the soil to maximize the yield by utilizing available micronutrient requirements from the soil, which could lead to competition for certain minerals in the soil particularly macro and micronutrients causing depletion of micronutrients in the soil [1]. Hence, recently, micronutrient requirements gained more importance in agriculture [2], especially in Cole crops like cauliflower. As these crops are very sensitive to the micronutrient deficiency. In India, cauliflower is a significant commercial winter vegetable. It has a high nutritional value and therapeutic benefit [3]. The agro-climatic conditions across the nation encourage the cultivation of cauliflower, even in the summer, with the possibility of export. According to Mengal and Kirkby (1987), it needs a balanced supply of plant nutrients, especially Iron, Manganese, copper, zinc, boron, and molybdenum. Cauliflower productivity is suboptimal as a result of insufficient soil fertility and unbalanced fertilization. The lack of micronutrients is especially pronounced in Indian soils. India's average output per hectare is low (15 t/ha) (TNAU CPG, 2022) One of the likely causes is that the crop is grown under less-than-ideal circumstances where nutritional deficiencies are frequent to improve agricultural yield and bring it to par with global standards, it is essential to implement agronomic practices and implement balanced fertilizers that include micronutrients.

Lack of Iron, Manganese, Zinc, Copper, and molybdenum is extremely common in cole crops which causes a number of anatomical, physiological, and natural changes (Souvik Kundu *et al,*2020). Whereas multiple studies on the micronutrient needs of cauliflower have been undertaken in various regions of the world as there is not much information on this topic for micronutrient-deficient soils. Furthermore, no studies on the impacts of micronutrients on the cultivation of cauliflower in the Coimbatore area have been published. Therefore, the goal of the current study was to evaluate how the impact of different micronutrient concentrations on the nutritional status, assimilation, and production of cauliflower in *Alfisols.*

2. MATERIALS AND METHODS

2.1 Experiment Location and Initial Soil Description

A Field study was conducted during 2022-23 in an A*lfisol* at a farmer's holding in Thondamuthur block, Coimbatore district. The experimental field's soil belongs to the Palaviduthi soil series (*Typic Rhodustalf*). The initial soil samples before commencing the experiment were collected and analyzed for their physical, physiochemical, and chemical parameters. The results of the initial soil analysis showed the soil is red, non-calcareous, sandy clay loam, alkaline (pH-8.18), non-saline (EC-0.11 dS m^{-1}), medium organic carbon (0.61g kg^{-1}) and high available $KMnO_4$-N (312 kg ha^{-1}), Olsen-P (29 kg ha^{-1}) and NH_4OAc-

K (398 kg ha^{-1}), respectively. The soil is deficient in available micronutrients Cu, Mo, Mn, Fe, and Zn.

2.2 Experimental Details

An experiment was conducted at Farmers Field, Deverayapuram, Thondamuthur, Coimbatore. The field experiment was conducted from March 2023 to May 2023 in a randomized block design consisting of 6 treatment combinations with four replications. The area is at an altitude of about 455 MSL with a Longitude of 76˚.81ˈ E and Latitude 10˚.987ˈ N. Test crop, cauliflower (Brassica oleracea var. botrytis L.) var. Early synthetic was used. The net area of the plot was 5m x 6m (30 m^2) . The spacing in the field followed paired row system of 60x45x45. FYM was applied as per treatment i.e., 20 t ha^{-1}. Quantative data was collected before harvesting the crop. Plant height (cm), Total no. of leaves, Leaf length (cm), Plant spread (cm), etc. were observed before harvesting. Data were analyzed by statistical package R, Microsoft Excel.

Table 1. Treatment details

Treatments	
T_1	Control
T_2	FYM alone @20 ton ha^{-1}
T_3	Micronutrient Mixture* @15 kg ha^{-1}
T_4	Micronutrient Mixture @20kg ha^{-1}
T_5	Micronutrient Mixture @25 kg ha^{-1}
T_6	Micronutrient Mixture @30 kg ha^{-1}

** Micronutrient Mixture indicates that different quantities of micronutrients are physically mixed exclusively for the growth of cauliflower crops. The respective quantity of Micronutrient (MN) mixture is mixed with Farmyard manure(FYM) @ 1:10 and incubated for 3-4 weeks to increase the solubility, and physical properties and powdered before application to ensure uniformity*

3. RESULTS AND DISCUSSION

3.1 Plant Height at the Vegetative Stage

The plant height was significantly influenced by the different treatments. The plant height shows maximum height at 30 DAP with the application of Micronutrient Mixture @ 30 kg ha^{-1} (T_6)(13.9 cm) it was statistically at par with the treatment with (T_5)(13.7 cm). Micronutrient Mixture @ 25 kg ha^{-1} The minimum height was seen in control (T_1)($6.5\ cm$) which was statistically at par with the treatment with FYM (T_2)($6.9\ cm$). There was an obvious increase in plant height with the age of the crop irrespective of the treatment. The vegetative period increases with micronutrient application by different uses by different micronutrients.

3.2 Plant Height at Curd Initiation Stage

Different treatments greatly impacted the plant height during the Curd Initiation stage. In comparison to the other treatments, plants with the (T_6) Micronutrient Mixture @ 30 kg ha^{-1} (19.9 cm) which was statistically at par with the treatment with (T_5) Micronutrient Mixture @25 kg ha^{-1} (13.7 cm) grows noticeably taller plants. The administration of micronutrients in the soil may be the cause of the variation.

3.3 Plant Height at Harvest

At the harvesting stage in treatment ($T_{6)}$ Micronutrient Mixture @ 30 kg ha^{-1} (22.6 cm)produced the highest plant height among the various treatments after seeding, which was 23.45% greater than the control treatment. In absolute control(17.3 cm), the minimum plant height was attained. With the progression of days after transplanting, micronutrients, and FYM increased plant height[4]. This might be attributed to the plants' ready access to nutrients from FYM and micronutrient sources, which improves plant foliage and boosts photosynthesis.

3.4 Number of Leaves at Curd Initiation Stage

The results previously mentioned demonstrated a sizable change in the number of leaves in a cauliflower plant under various treatments. It was shown that the micronutrient mixtures @30 kg ha^{-1} (9.6) and @25 kg ha^{-1} (8.4) produced the most cauliflower leaves. The control plot (5.3) had the fewest leaves overall. greater leaves result in greater photosynthesis, which might increase the amount of curd produced by cauliflower.

3.5 Number of Leaves at the Harvesting Stage

Significant changes in the number of leaves in cauliflower at the harvesting stage were shown by the data previously mentioned. The number of leaves from all combinations of treatments grows as the number of days increases. The Micronutrient Mixture @30 kg ha^{-1} (21.9) treatment had the highest maximum[5], followed by the Micronutrient Mixture @25 kg ha^{-1}(17.6), and the micronutrient Mixture @20 kg ha $^{-1}$ (16.9)and Micronutrient Mixture @15 kg ha $^{-1}$ (15.6)treatments are equal. Due to fewer leaves, less photosynthesis, and other yield qualities, the control (10.5) exhibits the lowest yield**.** FYM in all treatments also indirectly affects the number of leaves[6].

3.6 Plant Spread

The findings indicated that (T_6) treatment Micronutrient Mixture @30 kg ha^{-1} (78.4 cm)had the greatest plant spread, followed by (T_5) treatment @25 kg ha $^{-1}$ (71.7 cm)which was statically par with treatment ($T_{4)}$ treatment Micronutrient Mixture @20 kg ha^{-1}(69.5 cm).The least amount of plant spread that was seen at Control(56.4 cm) was comparable to the FYM-applied treatment(59.8 cm). In addition to this, the higher canopy coverage creates more shadowing, which aids in moisture retention. The more the plant spreads, the more it will be exposed to sunlight, which may contribute to an increase in photosynthesis [7][8].

3.7 Leaf area at 35 DAP

According to a statistical examination of the data, the treatment plot with the control treatment(58.4 cm^2) with no MN Mixture applied had the least leaf area, followed by the FYM alone (73.9 cm^2) applied treatment. Due to the application of FYM, the plant's height and leaf area were a little increased. [9]. The leaf area with the maximum leaf area was seen at Micronutrient Mixture @30 kg ha^{-1}(174.2 cm^2).Plant height, girth, leaf area, and the number of functional leaves all significantly improved as a result of the administration of micronutrients that contained the combination of B + Zn + Cu + Mn.[10]. Increased leaf area has a favorable correlation to increased photosynthesis and yield. When micronutrients are applied topically after 15, 45, and 75 days, there is a noticeable increase in leaf area that has a good impact on the production of cauliflower [11].

3.8 Leaf Area at 60 DAP

The findings revealed that the control plot (78.6 cm^2) without the application of FYM or Micronutrient Mixture had the least leaf area. Additional data revealed that the application of Micronutrient Mixture @30 kg ha^{-1} (205.3 cm^2) was administered had the greatest leaf area.Leaf area and crop productivity are positively correlated.Additionally, the micronutrient treatment increased yield by 1.6 times above control [12].

3.9 Curd Height

With the application of Micronutrient Mixture @30 kg ha^{-1} treated plot (9.55 cm), the curd height was greatly raised. When Micronutrient Mixture @25 kg/ha^{-1} (9.04 cm) was applied, the height of the curd was comparable to that of Micronutrient Mixture @20 kg/ha^{-1} (8.95 cm).The control plot(7.24 cm) recorded the lowest curd height. It directly affects cauliflower yield. FYM also effect the curd height [13] with the Micronutrient Mixture.

3.10 Curd Diameter

The plot treated with Micronutrient Mixture @30 kg ha^{-1} (12.8 cm)had the largest curd diameter. The treatment of several micronutrients had a substantial impact on the Curd diameter compared to the control [14]. The control (8.3 cm) had the lowest curd diameter because there were less leaves, fewer leaves fanned out, and these factors had a detrimental impact on photosynthesis.

3.11 Stem Diameter

The statistics indicate that there are few differences between the treatments because they have a greater genetic effect. Micronutrient Mixture @30 kg ha^{-1} (3.14 cm),Micronutrient Mixture @25 kg ha^{-1} (3.07 cm), and Micronutrient Mixture @20 kg ha^{-1}, (3.06 cm) ,which are statistically equivalent. Lowest measured stem diameter at control plot (2.2 cm).

3.12 Curd Weight

The results from the various treatments showed that the control condition(0.280 kg), where neither FYM nor MN Mixture was used, had the lowest curd weight recorded, followed by the FYM alone treatment plot(0.345 kg). Treatment with B and FYM resulted in an increase in the quantity, diameter, and number of lateral shoots on broccoli plants [15]. Due to the fact that different combinations of micronutrients in MN mixture have an impact on the yield characteristics of cauliflower and favorably influence the crop's curd weight, the highest curd weight was reported at the Micronutrient Mixture @30 kg ha^{-1} applied plot(1.07 kg). The highest curd weight and yield were obtained when boron and molybdenum were applied together [16].

Table 2. Micronutrient Mixture effect on plant height, no. of leaves, plant spread, leaf area of cauliflower in Micronutrient Deficient soils

Treatments	Plant height(cm)at the vegetative stage	Plant height(cm) at the curd initiation stage	Plant height(cm) At Harvesting stage	No. of leaves at curd initiation stage	No. of leaves at Harvesting stage	Plant spread (cm)
T_1: Control	6.5^{d}	12.2^{e}	17.3^{e}	5.3^{f}	10.5^{e}	56.4^{d}
T_2 :FYM alone	6.9^{d}	14.4^{d}	18.9^{d}	5.9^{e}	12.3^{e}	59.8^{d}
T_3:Micronutrient Mixture @15 kg ha^{-1}	9.4^{c}	15.9^{c}	19.6^{c}	6.2^{d}	15.6^{d}	64.1^{c}
T_4: Micronutrient Mixture @20 kg ha^{-1}	12.01^{b}	16.1^{c}	19.9^{c}	7.3^{c}	16.9^{c}	69.5^{b}
T_5: Micronutrient Mixture @25 kg ha^{-1}	13.7^{a}	17.7^{b}	21.7^{b}	8.4^{b}	17.6^{b}	71.7^{b}
T_6: Micronutrient Mixture @30 kg ha^{-1}	13.9^{a}	19.9^{a}	22.6^{a}	9.6^{a}	21.9^{a}	78.4^{a}
Sed	0.269	0.360	0.439	0.130	0.133	1.669
CD(P=0.05)	0.599	0.802	0.979	0.290	0.296	3.720
Significance	*	*	*	*	*	*

Means within the column followed by the same letter(s) do not differ significantly at 0.05%
**= Significance, **= highly siginificance*

Table 3. Micronutrient mixture effect on leaf area, curd height, curd diameter, stem diameter, curd weight, yield in micronutrient deficient soils

Treatment	Leaf area(cm^2) at 35 DAP	Leaf area(cm^2) at 60 DAP	Curd height (cm)	Curd diameter (cm)	Stem diameter (cm)	Curd weight(kg)	Yield (ton ha^{-1}
Control	58.4	78.6	7.24	8.3^{e}	2.2^{c}	0.280^{f}	9.8^{f}
FYM alone	73.9	98.6	8.32	10.6^{d}	2.44^{bc}	0.345^{e}	12.075^{e}
Micronutrient Mixture @15 kg ha^{-1}	107.7	142.4	8.55	11.1^{c}	2.34^{b}	0.812^{d}	28.42^{d}
Micronutrient Mixture @20 kg ha^{-1}	123.9	156.8	8.95	11.3^{bc}	3.06^{a}	0.857^{c}	29.995^{c}
Micronutrient Mixture @25 kg ha^{-1}	140.6	168.7	9.04	11.6^{b}	3.07^{a}	0.992^{b}	34.72^{b}
Micronutrient Mixture @30 kg ha^{-1}	174.2	205.3	9.55	12.8^{a}	3.14^{a}	1.07^{a}	37.45^{a}
Sed	1.852	2.450	0.105	0.221	0.063	0.012	0.636
CD(P=0.05)	4.126	5.458	0.303	0.493	0.141	0.026	1.416
Significance	**	**	*	*	*	*	**

Means within the column followed by the same letter(s) do not differ significantly at 0.05%
**= Significance, **= highly significance*

3.13 Yield

The analysis of the data showed that the Micronutrient Mixture @30 kg ha^{-1} treated plot(37.45 ton ha^{-1})had the highest yield, which may be attributed to factors such as increased root length, leaf count, and plant spreading. Cauliflower's growth, production, and quality are all boosted by micronutrients including boron, molybdenum, zinc, and $FeSo_4$ [17]. The control plot's(9.8 ton ha^{-1}) production was the lowest because there were fewer leaves, there was less photosynthesis, and there was less nutritional intake by the cauliflower.

4. CONCLUSION

This research depicted that the combined application of a micronutrient mixture @ 30 kg ha^{-1} incubated with FYM has a positive impact on the growth, yield, and quality of cauliflower in micronutrient-deficient soil under field conditions resulting in improved morphological characters and crop yield. Hence, it may be concluded that an optimum dose of 30kgha---can be recommended to cauliflower in micronutrient-deficient soils to enhance crop productivity

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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