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Impact of Micronutrients Foliar Application on the Growth Traits of Cauliflower (*Brassica oleracea* var. *botrytis* L.)

Rohit Kumar Singh [a++], M. K. Singh [b*], B. K. Singh [c#], A. K. Singh [c#], R. K. Maurya [d†], Priyanshu Singh [e‡] and Archit Singh [f‡]

[a] *Faculty of Agriculture, Agriculture College Garhwa, Birsa Agricultural University, Ranchi, India.*
[b] *Department of Vegetable Science, College of Horticulture, Banda University of Agriculture and Technology (BUAT), Banda (UP), India.*
[c] *Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP, India.*
[d] *Delhi Development Authority, India.*
[e] *CSIR- Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, India.*
[f] *ICAR- Central Institute for Cotton Research (CICR), Nagpur, India.*

Authors' contributions

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

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[++] *Assistant Professor cum Junior Scientist;*
[#] *Professor;*
[†] *Section Officer (Horticulture);*
[‡] *Research Associate;*
**Corresponding author: E-mail: manish961638@gmail.com;*

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ABSTRACT

An investigation was conducted during two successive winter season of 2018-19 and 2019-20 at the Agricultural Research farm of Banaras Hindu University, Varanasi, involving sixteen different treatments. These treatments included T1 (Control), T2 (Ammonium Molybdate (Mo) @ 0.20%), T3 (Ammonium Molybdate @ 0.30%), T4 (Ammonium Molybdate @ 0.40%), T5 (Boron @ 0.060%), T6 (Boron @ 0.080%), T7 (Boron @ 0.1%), T8 (Ammonium Molybdate @ 0.20% + Boron @ 0.060%), T9 (Ammonium Molybdate @ 0.20% + Boron @ 0.080%), T10 (Ammonium Molybdate @ 0.20% + Boron @ 0.1%), T11 (Ammonium Molybdate @ 0.30% + Boron @ 0.060%), T12 (Ammonium Molybdate @ 0.30% + Boron @ 0.080%), T13 (Ammonium Molybdate @ 0.30% + Boron @ 0.1%), T14 (Ammonium Molybdate @ 0.40% + Boron @ 0.060%), T15 (Ammonium Molybdate @ 0.40% + Boron @ 0.080%), and T16 (Ammonium Molybdate @ 0.40% + Boron @ 0.1%). These treatments were replicated three times using a Randomized Block Design. A recommended basal dose of nitrogen, phosphorus, and potassium (160:80:120 kg ha^{-1}) was applied using urea, single super phosphate (SSP), and muriate of potash (MOP), respectively, during both years of the experiment. Nitrogen was administered 50% as a basal dose and the remainder at 40 days after transplanting (DAT). The total rainfall during the crop growth period was 29.4 mm in 2018-19 and 93.9 mm in 2019-20. The Snowball-16 variety of cauliflower served as the test crop. Chelated zinc at a concentration of 0.5 g l^{-1} was applied to all treatments, while boron and molybdenum were applied according to the specific treatment. Other crop management practices were followed as per local recommendations. Results revealed that, the tallest plants, the most leaves per plant, and the highest crop growth rate (CGR) in cauliflower were significantly better with the application of (T16) Ammonium Molybdate at 0.40% combined with boron at 0.1%. This outcome was statistically similar to (T13) Ammonium Molybdate at 0.30% plus boron at 0.1% and (T10) Ammonium Molybdate at 0.20% with boron at 0.1%, surpassing other treatments in both years and in the combined analysis. Future research should focus on optimizing micronutrient spray formulations, application techniques, and cauliflower timing.

Keywords: Cauliflower; CGR; Boran; foliar spray; growth.

1. INTRODUCTION

Vegetables are rich in essential minerals and vitamins necessary for the proper functioning of human metabolic processes (Knez et al., 2023), which is why they are considered 'protective supplementary food.' Cultivating vegetables is a highly profitable venture, especially on small and marginal lands because of its high yield over a short period. As a source of farm income, it significantly influences agricultural development and national economy. There is a substantial demand for vegetables for both fresh consumption and processed products domestically, as well as for export, which can generate valuable foreign exchange for India. India ranks as the second largest vegetable producer globally, following China, with a wide variety of crops grown across the country. According to estimates, India produces 184.39 million tonnes of vegetables from 10.25 million hectares (Horticultural Statistics at a Glance, 2018). This accounts for about 13.38 percent of the global vegetable output, yet productivity remains low compared to that of developed nations. Consequently, current production does not satisfy national needs despite the potential for increased yield per unit area. There is also significant potential for exporting and processing vegetables. India leads the world in cauliflower production (Thamburaj & Singh, 2001), with commercial cultivation covering approximately 452.6 lakh hectares, yielding 86.68 lakh tonnes annually, and a productivity rate of 19.2 MT ha^{-1} (Horticultural Glance, 2018). The primary cauliflower-producing states in India include West Bengal, Bihar, Orissa, Uttar Pradesh, Assam, Haryana, Maharashtra, and Rajasthan. Uttar Pradesh alone has a cauliflower cultivation area of 17.53 thousand hectares, producing 400.81 thousand tons annually, contributing approximately 4.65 percent of the national cauliflower output (Horticultural Statistics at a Glance, 2018). India's vegetable production has shown significant growth and plays a crucial role in the country's agriculture sector. Horticulture, which includes vegetable crops, contributes 33% towards the Gross Value Added (GVA) of agriculture in India, enhancing farmers' income and providing rural employment (G & Makarabbi, 2023).

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is a nutrient-demanding crop and balanced fertilization is crucial for optimal productivity (Xiao et al., 2022). However, intensive farming and the exclusive use of nitrogenous fertilizers have led to soil deficiencies in secondary nutrients and micronutrients (Ali et al., 2008). Although micronutrients are required in minimal amounts, they are just as crucial as macronutrients. Their significance in controlling plant growth and yield has been well-documented (Hall et al., 2002). Among the various micronutrients, Boron, Molybdenum, Iron, Copper, Chlorine, Zinc, and Manganese, Boron and Molybdenum stand out because of their availability in soil, mobility within plants and soil, and their dependence on soil pH (Kumar et al., 2012). Micronutrients enhance the chemical makeup of curds and the overall health of plants (Hall et al., 2002). They boost seed germination, macronutrient absorption, production, and quality by improving photosynthetic efficiency and increasing the leaf metabolite content (Chaudhari et al., 2017). Additionally, they help reduce the occurrence of diseases, pests, and disorders while enhancing the postharvest quality of crops (Hemphill et al., 1982). A lack of these vital nutrients can greatly diminish crop yield and affect various physiological, morphological, and biochemical traits of cole crops during plant growth. Recently, it has been recognized that applying micronutrients such as Zinc (Zn), Boran (B), and Molybdenum (Mo) through foliar spraying is beneficial for increasing the yield, quality, and shelf life of cauliflower (Kotecha et al., 2011). Foliar application is considered an efficient and straightforward method for supplying plants with the necessary nutrients at sufficient concentrations (Alloway, 2018). Correcting micronutrient deficiencies via foliar application is effective because it allows for easy absorption through the leaves, leading to a profitable yield (Asad et al., 2003). Boron is essential for various plant functions, including glucose metabolism, plant reproduction, photosynthesis, and enzymatic activity (Monib et al., 2023). Molybdenum, on the other hand, is unique among micronutrients as it is the only one that becomes more available as soil pH increases (Thapa et al., 2021). Cauliflower plants frequently exhibit boron and Mo deficiencies, which manifest as browning of the curd and whiptail formation in leaves, respectively. These issues make curds unsuitable for consumption and significantly decrease yield. The addition of boron has been shown to notably enhance the diameter, weight, yield, and quality of cauliflower curds (Kumar et al., 2002). However, before applying boron fertilizer, it is crucial to confirm a suspected deficiency through soil and plant analyses, as excess boron can be extremely harmful to plants. Nevertheless, information on micronutrients for cauliflower cultivation in Uttar Pradesh is scarce. Considering the aforementioned facts regarding adequate information and research in this area, this study was conducted to examine the impact of foliar micronutrient application on the growth characteristics of cauliflower.

2. MATERIALS AND METHODS

The experiment was conducted over two consecutive winter seasons, 2018-19 and 2019-20, at the Vegetable Research Farm (South Block) of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, located in Varanasi, Uttar Pradesh ($25^0$10' N latitude and $83^0$03' E longitude, with an elevation of 128.93 meters above mean sea level). The soil at the site was sandy clay loam, with a pH of 7.36, an electrical conductivity of 0.28 dSm^{-1}, organic carbon content of 0.42%, available boron at 0.31 mg kg^{-1}, available zinc at 0.57 mg kg^{-1}, and available molybdenum at 0.26 ppm. The study employed a randomized block design with three replications, testing sixteen different micronutrient treatments: (T1) control, (T2) Ammonium Molybdate at 0.20%, (T3) Ammonium Molybdate at 0.30%, (T4) Ammonium Molybdate at 0.40%, (T5) Boron at 0.060%, (T6) Boron at 0.080%, (T7) Boron at 0.1%, (T8) Ammonium Molybdate at 0.20% + Boron at 0.060%, (T9) Ammonium Molybdate at 0.20% + Boron at 0.080%, (T10) Ammonium Molybdate at 0.20% + Boron at 0.1%, (T11) Ammonium Molybdate at 0.30% + Boron at 0.060%, (T12) Ammonium Molybdate at 0.30% + Boron at 0.080%, (T13) Ammonium Molybdate at 0.30% + Boron at 0.1%, (T14) Ammonium Molybdate at 0.40% + Boron at 0.060%, (T15) Ammonium Molybdate at 0.40% + Boron at 0.080%, and (T16) Ammonium Molybdate at 0.40% + Boron at 0.1%. Additionally, a uniform application of Zn (0.5 g l^{-1}) was administered across all treatments involving the Snowball-16 cauliflower variety. The crop was transplanted into the main field on November 14th, 2018 and November 16th, 2019. Foliar sprays were applied 20, 30, and 40 days post-transplantation.

2.1 Statistical Analysis and Interpretation of Data

The experimental data collected for various parameters were analyzed using Fisher's analysis of variance (ANOVA), following the guidelines set by Gomez & Gomez (1984). The significance level for the 'F' and 't' tests was set at p = 0.05. Critical difference values were determined when the F-test indicated statistical significance.

3. RESULTS

3.1 Plant Height

Significant differences in plant height were observed due to the foliar application of micronutrients at all growth stages across both experimental years. At 30 DAT, notable variations in plant height were evident among the treatments. The performance data indicated that plant height ranged from 17.84 to 23.51 cm in 2018-19, from 18.05 to 24.20 cm in 2019-20, and from 17.95 to 23.86 cm as a pooled mean. The highest plant heights (23.51 and 24.20 cm) were achieved with the foliar application of (T16) Ammonium Molybdate @ 0.40% + Boron @ 0.1%, which was statistically similar to (T13) Ammonium Molybdate @ 0.30% + Boron @ 0.1% and (T10) Ammonium Molybdate @ 0.20% + Boron @ 0.100%, outperforming the other treatments in both years. Similarly, the pooled mean data for plant height at 30 DAT was significantly influenced by the foliar application of micronutrients. The maximum pooled mean plant height (23.86 cm) was recorded with (T16) Ammonium Molybdate @ 0.40% + Boron @ 0.1%, which was statistically comparable to (T13) and (T10), while the minimum height was observed in T1 (Control). At 45 DAT, plant height data was significant in both years, ranging from 21.21 to 28.56 cm in 2018-19, from 22.19 to 29.38 cm in 2019-20, and from 21.70 to 28.97 cm as a pooled mean. The highest plant heights, 28.56 cm in the first year, 29.38 cm in the second year, and 28.97 cm in the pooled mean, were noted with (T16) Ammonium Molybdate @ 0.40% + Boron @ 0.1%, which was statistically on par with (T13) and (T10), while the lowest height was recorded in T1 (Control) across both years and the pooled mean.

3.2 Number of Leaves Plant^{-1}

The application of different micronutrients to the foliage had a notable effect on the leaf count of cauliflower plants. Thirty days after transplanting (DAT), the average number of leaves ranged from 5.02 to 7.62 in the first year, 5.16 to 7.86 in the second year, and 5.09 to 7.74 when averaged across both years. The highest leaf count, specifically 7.62 in the first year, 7.86 in the second year, and 7.74 in the pooled average was achieved with the treatment (T16) of Ammonium Molybdate at 0.40% combined with boron at 0.1%. This result was statistically similar to that of treatments (T13) with Ammonium Molybdate at 0.30% plus boron at 0.1% and (T10) with Ammonium Molybdate at 0.20% plus boron at 0.1%. The lowest leaf count per plant was observed in the control group (T1) across both years, and in the pooled average. At 45 DAT, the leaf count varied significantly, ranging from 7.69 to 11.21 in 2018-19, 7.98 to 11.88 in 2019-20, and 7.84 to 11.55 in the pooled average. The maximum number of leaves per plant, 11.21 in the first year, 11.88 in the second year, and 11.55 in the pooled average, was recorded with the (T16) treatment of Ammonium Molybdate at 0.40% plus boron at 0.1%. This was statistically comparable to treatments (T13) with Ammonium Molybdate at 0.30% and boron at 0.1%, and (T10) with Ammonium Molybdate at 0.20% and boron at 0.1%. The control group (T1) consistently showed the fewest leaves per plant across both years, and in the pooled average.

3.3 Crop Growth Rate (g plant^{-1} day^{-1})

The findings revealed that CGR was at its peak between 30-45 DAT compared to the other periods. There was a notable variation in the foliar application of micronutrients at all stages across both years. A detailed analysis of the data revealed that foliar application of micronutrients significantly affected crop growth rate in both experimental years. All treatments showed an increase in CGR compared to untreated plots, with the highest value at 0-30 DAT observed in (T16) Ammonium Molybdate @ 0.40% + Boron @ 0.1%, reaching 2.90 g plant^{-1} day^{-1} in the first year, 3.10 g plant^{-1} day^{-1} in the second year, and 3.00 g plant^{-1} day^{-1} on a pooled basis, followed by (T13) Ammonium Molybdate @ 0.30% + Boron @ 0.1% (2.73, 3.00, and 2.87 g plant^{-1} day^{-1}) and (T10) Ammonium Molybdate @ 0.20% + Boron @ 0.1% (2.67, 2.80, and 2.74 g plant^{-1} day^{-1}), with statistical similarities among these treatments. During 30-45 DAT, the CGR varied significantly from 3.80 to 7.20 g plant^{-1} day^{-1} in the second year, 4.0 to 7.67 g plant^{-1} day^{-1} in the second year, and 3.90 to 7.44 g plant^{-1} day^{-1} in the pooled data. The highest CGR, 7.20 g

Table 1. Plant height (cm) of cauliflower as influenced by foliar application of micro nutrients at different growth stages

Treatments	Plant height at 30 DAT			Plant height at 45 DAT		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T1: Control	17.84	18.05	17.95	21.21	22.19	21.70
T2: Ammonium Molybdate @ 0.20%	19.49	19.61	19.55	23.73	25.11	24.42
T3: Ammonium Molybdate @ 0.30%	19.62	19.83	19.73	24.11	25.34	24.73
T4: Ammonium Molybdate @ 0.40%	19.88	20.27	20.08	24.56	25.76	25.16
T5: Boron @ 0.060%	18.75	18.91	18.83	22.48	24.09	23.29
T6: Boron @ 0.080%	19.01	19.12	19.07	22.78	24.63	23.71
T7: Boron @ 0.100%	19.23	19.42	19.33	23.31	24.89	24.10
T8: Ammonium Molybdate @ 0.20% + Boron @ 0.060%	20.11	20.51	20.31	24.89	26.02	25.46
T9: Ammonium Molybdate @ 0.20% + Boron @ 0.080%	21.05	21.89	21.47	26.02	26.99	26.51
T10: Ammonium Molybdate @ 0.20% + Boron @ 0.100%	22.76	23.26	23.01	27.37	28.19	27.78
T11: Ammonium Molybdate @ 0.30% + Boron @ 0.060%	20.64	20.87	20.76	25.37	26.42	25.90
T12: Ammonium Molybdate @ 0.30% + Boron @ 0.080%	21.67	22.26	21.97	26.42	27.37	26.90
T13: Ammonium Molybdate @ 0.30% + Boron @ 0.100%	23.12	23.90	23.51	27.94	28.71	28.33
T14: Ammonium Molybdate @ 0.40% + Boron @ 0.060%	20.78	21.15	20.97	25.79	26.73	26.26
T15: Ammonium Molybdate @ 0.40% + Boron @ 0.080%	22.04	22.73	22.39	26.98	27.72	27.35
T16: Ammonium Molybdate @ 0.40% + Boron @ 0.100%	23.51	24.20	23.86	28.56	29.38	28.97
SEm+	0.42	0.46	0.45	0.51	0.54	0.52
LSD Q=0.05)	1.29	1.41	1.38	1.53	1.63	1.58

Table 2. Number of leaves plant^{-1} of cauliflower as influenced by foliar application of micro nutrients at different growth stages

Treatments	Leaves plant^{-1} at 30 DAT			Leaves plant^{-1} at 45 DAT		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T1: Control	5.02	5.16	5.09	7.69	7.98	7.84
T2: Ammonium Molybdate @ 0.20%	5.70	5.79	5.75	9.02	9.11	9.07
T3: Ammonium Molybdate @ 0.30%	5.78	5.83	5.81	9.24	9.37	9.31
T4: Ammonium Molybdate @ 0.40%	5.89	5.97	5.93	9.54	9.62	9.58
T5: Boron @ 0.060%	5.45	5.52	5.49	8.42	8.54	8.48
T6: Boron @ 0.080%	5.59	5.67	5.63	8.63	8.78	8.71
T7: Boron @ 0.100%	5.64	5.71	5.68	8.94	9.03	8.99
T8: Ammonium Molybdate @ 0.20% + Boron @ 0.060%	5.99	6.02	6.01	9.68	9.87	9.78
T9: Ammonium Molybdate @ 0.20% + Boron @ 0.080%	6.53	6.68	6.61	10.32	10.42	10.37
T10: Ammonium Molybdate @ 0.20% + Boron @ 0.100%	7.28	7.37	7.33	10.58	11.12	10.85
T11: Ammonium Molybdate @ 0.30% + Boron @ 0.060%	6.09	6.19	6.14	10.01	10.11	10.06
T12: Ammonium Molybdate @ 0.30% + Boron @ 0.080%	6.71	6.92	6.82	10.43	10.67	10.55
T13: Ammonium Molybdate @ 0.30% + Boron @ 0.100%	7.46	7.52	7.49	11.06	11.45	11.26
T14: Ammonium Molybdate @ 0.40% + Boron @ 0.060%	6.24	6.43	6.34	10.18	10.29	10.24
T15: Ammonium Molybdate @ 0.40% + Boron @ 0.080%	6.99	7.19	7.09	10.16	10.82	10.49
T16: Ammonium Molybdate @ 0.40% + Boron @ 0.100%	7.62	7.86	7.74	11.21	11.88	11.55
SEm+	0.19	0.21	0.20	0.32	0.33	0.33
LSD Q=0.05)	0.59	0.63	0.61	0.98	1.01	0.99

Table 3. Crop growth rate (g plant^{-1} day^{-1}) of cauliflower as influenced by foliar application of micro nutrients at different growth stages

Treatments	0-30 DAT			30-45 DAT		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T1: Control	1.57	1.60	1.59	3.80	4.00	3.90
T2: Ammonium Molybdate @ 0.20%	1.87	1.87	1.87	4.53	4.67	4.60
T3: Ammonium Molybdate @ 0.30%	1.90	1.97	1.94	4.73	4.80	4.77
T4: Ammonium Molybdate @ 0.40%	1.93	1.97	1.95	4.73	4.93	4.83
T5: Boron @ 0.060%	1.70	1.73	1.72	4.13	4.27	4.20
T6: Boron @ 0.080%	1.77	1.80	1.79	4.33	4.33	4.33
T7: Boron @ 0.100%	1.80	1.83	1.82	4.33	4.53	4.43
T8: Ammonium Molybdate @ 0.20% + Boron @ 0.060%	2.00	2.07	2.04	4.93	5.07	5.00
T9: Ammonium Molybdate @ 0.20% + Boron @ 0.080%	2.20	2.30	2.25	5.47	5.60	5.54
T10: Ammonium Molybdate @ 0.20% + Boron @ 0.100%	2.67	2.80	2.74	6.53	6.93	6.73
T11: Ammonium Molybdate @ 0.30% + Boron @ 0.060%	2.07	2.10	2.09	5.07	5.20	5.14
T12: Ammonium Molybdate @ 0.30% + Boron @ 0.080%	2.33	2.40	2.37	5.73	5.87	5.80
T13: Ammonium Molybdate @ 0.30% + Boron @ 0.100%	2.73	3.00	2.87	6.73	7.33	7.03
T14: Ammonium Molybdate @ 0.40% + Boron @ 0.060%	2.13	2.20	2.17	5.27	5.33	5.30
T15: Ammonium Molybdate @ 0.40% + Boron @ 0.080%	2.50	2.60	2.55	6.07	6.33	6.20
T16: Ammonium Molybdate @ 0.40% + Boron @ 0.100%	2.90	3.10	3.00	7.20	7.67	7.44
SEm+	0.10	0.12	0.11	0.22	0.24	0.23
LSD Q=0.05)	0.31	0.38	0.34	0.68	0.77	0.71

Table 4. Effect of foliar application of micronutrients on curd yield (tonn ha^{-1}) of cauliflower

Treatments	Curd yield (tonn ha^{-1})		
	2018-19	**2019-20**	**Pooled**
T1: Control	34.60	36.65	35.62
T2: Ammonium Molybdate @ 0.20%	42.80	43.48	43.14
T3: Ammonium Molybdate @ 0.30%	44.16	45.53	44.84
T4: Ammonium Molybdate @ 0.40%	44.84	46.21	45.53
T5: Boron @ 0.060%	38.01	39.38	38.70
T6: Boron @ 0.080%	40.06	40.06	40.06
T7: Boron @ 0.100%	40.75	42.11	41.43
T8: Ammonium Molybdate @ 0.20% + Boron @ 0.060%	46.89	48.26	47.58
T9: Ammonium Molybdate @ 0.20% + Boron @ 0.080%	52.36	54.41	53.39
T10: Ammonium Molybdate @ 0.20% + Boron @ 0.100%	64.66	68.76	66.71
T11: Ammonium Molybdate @ 0.30% + Boron @ 0.060%	48.26	49.63	48.94
T12: Ammonium Molybdate @ 0.30% + Boron @ 0.080%	55.78	57.14	56.46
T13: Ammonium Molybdate @ 0.30% + Boron @ 0.100%	66.71	73.54	70.12
T14: Ammonium Molybdate @ 0.40% + Boron @ 0.060%	50.31	51.68	50.99
T15: Ammonium Molybdate @ 0.40% + Boron @ 0.080%	59.88	62.61	61.24
T16: Ammonium Molybdate @ 0.40% + Boron @ 0.100%	71.49	76.96	74.22
SEm+	1.12	1.20	1.14
LSD Q=0.05)	3.50	3.61	3.56

plant^{-1} day^{-1} (2018-19), 7.67 g plant^{-1} day^{-1} (2019-20), and 7.44 g plant^{-1} day^{-1} (pooled mean), was recorded with the application of (T16) Ammonium Molybdate @ 0.40% + Boron @ 0.1%, which was statistically comparable to (T13) Ammonium Molybdate @ 0.30% + Boron @ 0.1% with 6.73 g plant^{-1} day^{-1} (2018-19), 7.33 g plant^{-1} day^{-1} (2019-20), and 7.03 g plant^{-1} day^{-1} (pooled mean), and (T10) Ammonium Molybdate @ 0.20% + Boron @ 0.1% with 6.53 g plant^{-1} day^{-1} (2018-19), 6.93 g plant^{-1} day^{-1} (2019-20), and 6.73 g plant^{-1} day^{-1} (pooled mean).

3.4 Grain Yield (Tonn ha^{-1})

The data presented in Table 4 indicate that the combined application of Ammonium Molybdate and Boron resulted in higher curd yields than their individual applications. Treatment T16, comprising 0.40% Ammonium Molybdate and 0.1% boron, consistently yielded the highest curd production across both years and in the pooled data. Conversely, the control treatment (T1) exhibited the lowest curd yield, underscoring the positive effect of micronutrient application on cauliflower production. The results demonstrate a clear dose-response relationship, with higher concentrations of both Ammonium Molybdate and Boron generally leading to increased curd yields. Treatment T13, which combined Ammonium Molybdate at 0.30% and boron at 0.1%, consistently produced the second-highest yields, suggesting that the optimal concentrations may lie between T13 and T16. The significant differences in yield between the treatments, as indicated by the LSD values, emphasize the importance of proper micronutrient management in cauliflower cultivation.

4. DISCUSSION

The noticeable increase in plant height can be attributed to increased cell division and elongation facilitated by boron. This may be due to the provision of micronutrients and availability of nutrients in the soil under favourable conditions. Additionally, the increase in plant height could be linked to an enhanced root system, which allows for better absorption of water and nutrients from the soil, as well as the utilization of more nutrients through foliar application of micronutrients such as boron and molybdenum. This, in turn, improves various plant organs and the plant as a whole. These findings are consistent with those of Moniruzzaman et al., (2007) for broccoli, Singh et al., (2011) for cauliflower, Kumar et al. (2012) for cauliflower, and Devi et al. (2012) for cabbage. The beneficial effect of boron and Mo on leaf number may be due to the availability of essential plant nutrients at different growth stages, which accelerates metabolic processes, sugar metabolism, solute translocation, and protein synthesis, ultimately leading to the production of more leaves. A similar outcome was reported by Chaudhari et al. (2017) for cauliflower. The increase in growth characteristics could be attributed to the availability of essential plant nutrients in the necessary quantities during various growth stages. This availability may accelerate the plant's metabolic processes, including sugar metabolism, solute translocation, and protein synthesis, potentially leading to longer roots and stalks. Chaudhari et al., (2017) observed similar outcomes in cauliflower. These results align with the findings of Srichandan et al., (2015); Sharma, (2016) and Meena et al., (2018).

5. CONCLUSION

Cauliflower is an important vegetable crop in both India and Uttar Pradesh, but achieving optimal nutrient management is crucial for its enhanced growth. The data suggest that the tallest plants, greatest number of leaves per plant, and highest crop growth rate (CGR) in cauliflower were statistically superior to the application of (T16) Ammonium Molybdate at 0.40% combined with boron at 0.100%. This result was statistically comparable to (T13) Ammonium Molybdate at 0.30% plus boron at 0.100% and (T10) Ammonium Molybdate at 0.20% with boron at 0.100%, outperforming other treatments across both years and in the pooled analysis. It can be concluded that foliar application of the micronutrient Ammonium Molybdate at 0.40% and boron at 0.100% is advantageous for promoting greater cauliflower growth in eastern Uttar Pradesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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