The Pharma Innovation Journal 2022; 11(1): 734-737

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 734-737

www.thepharmajournal.com
Received: 01-10-2021
Accepted: 09-12-2021

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Effect of foliar application of micronutrients on growth characters of cauliflower (*Brassica oleracea* var. *botrytis* L.)

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Abstract
A field experimented was conducted at Vegetable Research Farm (South Block), Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during two successive winter season of 2018-19 and 2019-20 to study the effect of foliar application of micronutrients on growth characters of cauliflower. The results reveals that the maximum plant height (33.67, 34.35 and 34.01 cm during 2018-19, 2019-20 and pooled analysis, respectively), number of leaves plant^{-1} (18.96, 19.45 and 19.21 during 2018-19, 2019-20 and pooled analysis, respectively), leaf length (18.96, 19.45 and 19.21 cm during 2018-19, 2019-20 and pooled analysis, respectively) and leaf width (27.11, 28.39 and 27.75 cm during 2018-19, 2019-20 and pooled analysis, respectively) were observed with application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which was statistically at par with (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100% than rest of the treatments during both the years as well as pooled analysis. However, least value of all growth characters was observed with (T_1) control.

Keywords: Cauliflower, characters, micronutrients and pooled

Introduction
The vegetables contain large amounts of minerals and vitamins which are required for normal functioning of human metabolic processes therefore they are regarded as 'protective supplementary food'. India is the world's second largest producer of vegetables next to China along with number of varieties grown in the country. According to an estimate, India produces 184.39 million tonnes of vegetables from an area of 10.25 million hectares (Horticultural Statistics at a Glance, 2018) [8]. Thus, India shares about 13.38 per cent of world output of vegetables, but productivity is very low as compared to developed countries. So, presently it does not meet even national need inspite of ample scope to increase in production per unit area. There is also equal scope for export and processing of vegetables.

The present production and consumption of vegetables in the country are very inadequate, being only about one-fourth to one-third of the requirement (ICMR, 2015) [9]. Low consumption of vegetables in India is really a problem as general people are suffering from several diseases and physiological disorders like, malnutrition. This is because the balance nutrition to the body cannot be supplied with the result that resistance could not be developed. Therefore, it is an urgent need to increase the vegetable production by bringing more area under cultivation and adoption of improved technologies, as well as the unit area production of vegetables by scientific cultivation. Cauliflower is a heavy feeder crop, balanced fertilization is very important for better productivity. Due to the intensive cultivation and judicious use of only nitrogenous fertilizers, soils are become deficit in secondary and micronutrients (Ali *et al.*, 2008) [1]. The micronutrients though required in small quantities are as important as macronutrients. The role of micronutrients in regulation of plant growth and yield is established (Hall *et al.*, 2002) [7]. Among all (Boron, Molybdenum, Iron, Copper, Chlorine, Zinc and Manganese), Boron and Molybdenum are most important than others due to its availability in soil, mobility in plants and soil and more dependency upon pH in soil (Kumar *et al.*, 2012) [11]. Micronutrient improves the chemical composition of curd and general condition of the plant (Swan *et al.*, 2001 and Hall *et al.*, 2002) [15, 7].

Deficiency of these essential nutrients can significantly reduce crop yield and can even affect various micronutrients in different physiological, morphological and bio-chemical characteristics of cole crops from plant growth.

Now days, it is realized that foliar spray of micronutrients (Zn, B and Mo) has proved beneficial to increase yield, quality and improving shelf life of cauliflower (Kotecha *et al*., 2011) [10]. Foliar application of micronutrients can be considered one of the easier and effective methods, to deliver the needed nutrients to plants in adequate concentrations (Alloway, 2018) [2]. However, correcting micronutrient deficiencies through foliar application is an effective method due to easy absorption through leaves results in getting profitable yield (Asad *et al*., 2003) [3]. However, information regarding micro nutrients for cauliflower production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and space related research, the present investigation was undertaken to find out the effect of foliar application of micronutrients on growth characters of cauliflower.

Materials and Methods

An experiment was conducted during two successive winter season of 2018-19 and 2019-20, at Vegetable Research Farm (South Block), Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (situated at 25º10' N latitude and 83º03' E longitude with an altitude of 128.93 m above mean sea level). The soil was sandy clay loam in texture having a pH of 7.36, EC 0.28 (dSm^{-1}) organic Carbon 0.42%, available boron 0.31 mg kg^{-1}, available zinc 0.57 mg kg^{-1} and available molybdenum 0.26 ppm. The experiment was conducted in randomized block design with replicate thrice consisted of sixteen micronutrient treatments *viz.* (T_1) control, (T_2) Ammonium Molybdate (Mo) @ 0.20%, (T_3) Ammonium Molybdate (Mo) @ 0.30%, (T_4) Ammonium Molybdate (Mo) @ 0.40%, (T_5) Boron @ 0.060%, (T_6) Boron @ 0.080%, (T_7) Boron @ 0.100%, (T_8) Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%, (T_9) Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%, (T_{10}) Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%, (T_{11}) Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%, (T_{12}) Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%, (T_{13}) Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%, (T_{14}) Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%, (T_{15}) Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080% and (T_{16}) Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%. Application of Zn 0.5 g l^{-1} was also applied equal in all the treatments involving Snowball-16 variety of cauliflower. The crop was transplanted in the 14th and 16th November during 2018 and 2019, respectively in main field. The foliar spray was applied at 20, 30 and 40 days after transplanting. All growth parameters were observed with randomly selected five plants with the help of measuring tape (cm).

Statistical analysis and interpretation of data

Data recorded on various parameters of the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The levels of significance used in 'F' and 't' test was p= 0.05. Critical difference values were calculated where F test was found significant.

Results and Discussions

The outcomes of the study (Table 1) showed that foliar application of micronutrients significantly influence the growth characters of cauliflower are presented in Table 1-4. Data indicated that among the treatments, highest plant height at 60 DAT (33.67, 34.35 and 34.01 cm during 2018-19, 2019-20 and pooled analysis, respectively) was observed with application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which was statistically at par with (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100% than rest of the treatments during both the years as well as pooled analysis. However, least plant height was observed with (T_1) control. This perceptible increase in plant height is due to an enhancement in cell multiplication and cell elongation in the presence of boron. It might be due to supply of micronutrients and availability of uptake nutrients in soil due to favourable conditions. The increase in plant height also may be attributed to improved root system of plants resulting in absorption of water and nutrients from soil and utilization of more nutrients through foliar spray of micronutrient (B and Mo) and consequently they improved different plant organs and also entire plant. These results are close conformity with findings of Moniruzzaman *et al.* (2007) [12] in broccoli, Singh *et al.* (2011) [14] in cauliflower, Kumar *et al.* (2012) [11] in also cauliflower and Devi *et al.* (2012) [5] in cabbage.

Data enumerated in Table 2 varied significantly for micronutrients in respect to number of leaves $plant^{-1}$ of cauliflower for both the years. Scrutiny of data revealed that, application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% recorded significantly higher number of leaves $plant^{-1}$ (18.96, 19.45 and 19.21 during 2018-19, 2019-20 and pooled analysis, respectively) which was statistically at par with application of (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100% than rest of the treatments during both the years as well as pooled analysis. Whereas, least number of leaves $plant^{-1}$ was found with control (T_1) during course of investigation. The positive influence of boron and molybdenum on number of leaves 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) [4] in cauliflower.

A cursory glance of Table 3 revealed that micronutrients had significant effect on leaf length of cauliflower during both the years of study. Significantly higher leaf length (18.96, 19.45 and 19.21 cm during 2018-19, 2019-20 and pooled analysis, respectively) was recorded under application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which was statistically at par with (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100% than rest of the treatments during both the years as well as pooled analysis. However, least leaf length was observed with (T_1) control.

Leaf width were also significantly influenced with foliar application of micronutrients showed in Table 4. Data indicated that among the treatments, significantly highest leaf width at 60 DAT (27.11, 28.39 and 27.75 cm during 2018-19, 2019-20 and pooled analysis, respectively) was observed with application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which was statistically at par with (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100%

than rest of the treatments during both the years as well as pooled analysis. However, least leaf width was observed with (T_1) control. Among the micro nutrients, protein synthesis, development of cell walls, carbohydrate metabolism, that might have resulted in increase the leaf and leaf width. The same result was also reported by Saha *et al*. (2010) [13].

Table 1: Effect of micronutrients on plant height (cm) of cauliflower at 60 DAT

Notation	Treatments	Plant height (cm)		
		2018-19	2019-20	Pooled
T_1	Control	24.19	25.67	24.93
T_2	Ammonium Molybdate (Mo) @ 0.20%	27.64	29.11	28.38
T_3	Ammonium Molybdate (Mo) @ 0.30%	28.37	29.49	28.93
T_4	Ammonium Molybdate (Mo) @ 0.40%	28.81	30.06	29.44
T_5	Boron @ 0.060%	26.23	27.59	26.91
T_6	Boron @ 0.080%	26.61	28.09	27.35
T_7	Boron @ 0.100%	27.10	28.67	27.89
T_8	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%	29.43	30.56	30.00
T_9	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%	30.69	31.84	31.27
T_{10}	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%	32.23	33.11	32.67
T_{11}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%	29.84	30.92	30.38
T_{12}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%	31.18	32.01	31.60
T_{13}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%	32.87	33.98	33.43
T_{14}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%	30.21	31.48	30.85
T_{15}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080%	31.94	32.50	32.22
T_{16}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%	33.67	34.35	34.01
S.Em±		0.55	0.58	0.57
LSD (P=0.05)		1.69	1.78	1.73

**Chelated Zn @ 0.5 g l^{-1} was applied in all the treatments

Table 2: Effect of micronutrients on number of leaves plant^{-1} of cauliflower at 60 DAT

Notation	Treatments	Number of leaves plant^{-1}		
		2018-19	2019-20	Pooled
T_1	Control	11.58	11.94	11.76
T_2	Ammonium Molybdate (Mo) @ 0.20%	14.52	14.63	14.58
T_3	Ammonium Molybdate (Mo) @ 0.30%	14.79	14.99	14.89
T_4	Ammonium Molybdate (Mo) @ 0.40%	15.12	15.37	15.25
T_5	Boron @ 0.060%	13.59	13.71	13.65
T_6	Boron @ 0.080%	13.81	13.96	13.89
T_7	Boron @ 0.100%	14.10	14.26	14.18
T_8	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%	15.68	15.81	15.75
T_9	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%	16.41	16.67	16.54
T_{10}	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%	17.41	17.89	17.65
T_{11}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%	15.97	16.02	16.00
T_{12}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%	16.94	17.11	17.03
T_{13}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%	18.35	18.64	18.50
T_{14}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%	16.01	16.29	16.15
T_{15}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080%	17.26	17.62	17.44
T_{16}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%	18.96	19.45	19.21
S.Em±		0.54	0.58	0.56
LSD (P=0.05)		1.64	1.76	1.69

**Chelated Zn @ 0.5 g l^{-1} was applied in all the treatments

Table 3: Effect of micronutrients on number of leaf length (cm) of cauliflower at 60 DAT

Notation	Treatments	Leaf length (cm)		
		2018-19	2019-20	Pooled
T_1	Control	11.58	11.94	11.76
T_2	Ammonium Molybdate (Mo) @ 0.20%	14.52	14.63	14.58
T_3	Ammonium Molybdate (Mo) @ 0.30%	14.79	14.99	14.89
T_4	Ammonium Molybdate (Mo) @ 0.40%	15.12	15.37	15.25
T_5	Boron @ 0.060%	13.59	13.71	13.65
T_6	Boron @ 0.080%	13.81	13.96	13.89
T_7	Boron @ 0.100%	14.10	14.26	14.18
T_8	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%	15.68	15.81	15.75
T_9	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%	16.41	16.67	16.54
T_{10}	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%	17.41	17.89	17.65
T_{11}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%	15.97	16.02	16.00
T_{12}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%	16.94	17.11	17.03

T_{13}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%	18.35	18.64	18.50
T_{14}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%	16.01	16.29	16.15
T_{15}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080%	17.26	17.62	17.44
T_{16}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%	18.96	19.45	19.21
S.Em±		0.54	0.58	0.56
LSD (P=0.05)		1.64	1.76	1.69

**Chelated Zn @ 0.5 g l^{-1} was applied in all the treatments

Table 4: Effect of micronutrients on number of leaf width (cm) of cauliflower at 60 DAT

Notation	Treatments	Leaf width (cm)		
		2018-19	**2019-20**	**Pooled**
T_1	Control	19.87	20.48	20.18
T_2	Ammonium Molybdate (Mo) @ 0.20%	22.89	23.87	23.38
T_3	Ammonium Molybdate (Mo) @ 0.30%	23.43	24.12	23.78
T_4	Ammonium Molybdate (Mo) @ 0.40%	23.56	24.37	23.97
T_5	Boron @ 0.060%	21.67	22.48	22.08
T_6	Boron @ 0.080%	22.12	22.92	22.52
T_7	Boron @ 0.100%	22.63	23.51	23.07
T_8	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%	23.86	24.61	24.24
T_9	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%	24.73	25.53	25.13
T_{10}	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%	26.23	26.99	26.61
T_{11}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%	23.94	24.89	24.42
T_{12}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%	24.91	25.87	25.39
T_{13}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%	26.73	27.54	27.14
T_{14}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%	24.24	25.12	24.68
T_{15}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080%	25.12	26.11	25.62
T_{16}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%	27.11	28.39	27.75
S.Em±		0.66	0.68	0.67
LSD (P=0.05)		1.98	2.06	2.03

**Chelated Zn @ 0.5 g l^{-1} was applied in all the treatments

Conclusion

From data presented it might reasonably be argued that the highest plant height, number of leaves plant-1, leaf length and leaf width of cauliflower was recorded with application of application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which was statistically at par with (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% and (T_{10}) Ammonium Molybdate @ 0.20% + Boron @ 0.100% than rest of the treatments during both the years as well as pooled analysis.

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