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Effect of foliar application of micronutrients on yield and economics 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 winter season of 2017-2018 and 2018-2019 to study the effect of foliar application of micronutrients on curd yield and economics of cauliflower. The results reveals that the maximum curd yield of cauliflower (92.08, 99.12 and 95.60 kg plot^{-1} during 2018-19, 2019-20 and pooled analysis, respectively) and maximum gross returns (₹ 187600 & 208800 ha^{-1}), net returns (₹ 134723 & 154343 ha^{-1}) and B: C ratio of the magnitude 2.55 and 2.83 were obtained 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% over rest of the treatments during both the years as well as pooled analysis. However, least value of curd yield, gross returns, net returns and B:C ratio were observed with (T_1) control.

Keywords: Cauliflower, economics, curd yield and net returns

Introduction
Vegetables play a very important role in the human diet. They are valuable roughages, which promote digestion and help to prevent constipation. They supply carbohydrate, fats, protein, vitamins and mineral elements. 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) [6]. 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) [5]. 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) [8]. Micronutrient improves the chemical composition of curd and general condition of the plant (Swan *et al*., 2001 and Hall *et al*., 2002) [14, 5].

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) [7]. 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 sparce related research, the present investigation was undertaken to find out the effect of foliar application of micronutrients on yield and economics 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. The crop was harvested at physiological maturity and curd yield were recorded.

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 different micronutrients significantly influence the yield of cauliflower is presented in Table 1. Data indicated that among the treatments, highest curd yield $plot^{-1}$ of cauliflower ((92.08, 99.12 and 95.60 kg $plot^{-1}$ 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% over rest of the treatments during both the years as well as pooled analysis. However, least curd yield was observed with (T_1) control. Increase in curd yield was due to promotive effects of molybdenum on vegetative growth enhanced curd yield which ultimately lead 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 Sharma (2002) [12]; Kumar and Choudhary (2002) [9].

A cursory glance of Table 2 revealed that micronutrients had effect on relative economics of cauliflower during both the years of study. The maximum gross returns (₹ 187600 & 208800 ha^{-1}), net returns (₹ 134723 & 154343 ha^{-1}) and B: C ratio of the magnitude 2.55 and 2.83 were obtained 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% over rest of the treatments during both the years as well as pooled analysis. However, maximum cost of cultivation (₹ 52877 & 54457 ha^{-1}) was recorded with application of (T_{16}) Ammonium Molybdate @ 0.40% + Boron @ 0.100% which is closely followed by (T_{15}) Ammonium Molybdate @ 0.40% + Boron @ 0.80% and (T_{13}) Ammonium Molybdate @ 0.30% + Boron @ 0.100% over rest of the treatments during both the experimental years. While, minimum values of cost of cultivation (₹ 51337 & 52917 ha^{-1}), gross returns (₹ 83650 & 91800 ha^{-1}) and net returns (₹ 134723 & 154343 ha^{-1}) was recorded with (T_1) control. It may be because that in the presence of B_2M_2 all the physiological activities may run fast and efficiently, which has resulted for better growth and ultimately the higher yield and highest net income as compared to untreated control. This might also be because of higher curd yield as compared to other treatments which led to higher net returns. The above result is in agreement with the findings of Patel *et al.* (2011) [11]; Sharma (2016) [13]; Moklikar *et al.* (2018) [10] in cauliflower.

Table 1: Effect of foliar application of micronutrients on $plot^{-1}$ curd yield (kg) of cauliflower

Notation	Treatments	Curd yield $plot^{-1}$ (kg)		
		2018-19	2019-20	Pooled
T_1	Control	44.56	47.20	45.88
T_2	Ammonium Molybdate (Mo) @ 0.20%	55.12	56.00	55.56
T_3	Ammonium Molybdate (Mo) @ 0.30%	56.88	58.64	57.76
T_4	Ammonium Molybdate (Mo) @ 0.40%	57.76	59.52	58.64
T_5	Boron @ 0.060%	48.96	50.72	49.84
T_6	Boron @ 0.080%	51.60	51.60	51.60
T_7	Boron @ 0.100%	52.48	54.24	53.36
T_8	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.060%	60.40	62.16	61.28
T_9	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.080%	67.44	70.08	68.76
T_{10}	Ammonium Molybdate (Mo) @ 0.20% + Boron @ 0.100%	83.28	88.56	85.92

T_{11}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.060%	62.16	63.92	63.04
T_{12}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.080%	71.84	73.60	72.72
T_{13}	Ammonium Molybdate (Mo) @ 0.30% + Boron @ 0.100%	85.92	94.72	90.32
T_{14}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.060%	64.80	66.56	65.68
T_{15}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.080%	77.12	80.64	78.88
T_{16}	Ammonium Molybdate (Mo) @ 0.40% + Boron @ 0.100%	92.08	99.12	95.60
S.Em±		3.06	3.52	3.40
LSD (P=0.05)		9.21	10.59	10.28

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

Table 2: Effect of foliar application of micronutrients on relative economics (₹ ha^{-1}) of cauliflower

Treatments	Cost of cultivation (₹ ha^{-1})		Gross returns (₹ ha^{-1})		Net returns (₹ ha^{-1})		B: C ratio	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1	51337	52917	83650	91800	32313	38883	0.63	0.73
T_2	51827	53407	106750	111600	54923	58193	1.06	1.09
T_3	52072	53652	110600	117720	58528	64068	1.12	1.19
T_4	52317	53897	112350	119520	60033	65623	1.15	1.22
T_5	51524	53104	93100	99720	41576	46616	0.81	0.88
T_6	51710	53290	99050	101880	47340	48590	0.92	0.91
T_7	51897	53477	100800	107640	48903	54163	0.94	1.01
T_8	52014	53594	118300	125640	66286	72046	1.27	1.34
T_9	52200	53780	133700	143280	81500	89500	1.56	1.66
T_{10}	52387	53967	168350	185040	115963	131073	2.21	2.43
T_{11}	52259	53839	122150	129600	69891	75761	1.34	1.41
T_{12}	52445	54025	143150	151200	90705	97175	1.73	1.80
T_{13}	52632	54212	173950	198720	121318	144508	2.31	2.67
T_{14}	52504	54084	127750	135360	75246	81276	1.43	1.50
T_{15}	52690	54270	154700	167040	102010	112770	1.94	2.08
T_{16}	52877	54457	187600	208800	134723	154343	2.55	2.83

**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 curd yield of cauliflower, gross returns, net returns and B:C ratio was recorded 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% over rest of the treatments during both the years as well as pooled analysis**.**

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