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Effect of foliar application of various micronutrients on growth characters of cabbage (*Brassica oleracea* var. *capitata* 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 various micronutrients on growth characters of cabbage. The results reveals that the maximum plant height (35.28, 37.67 and 36.47 cm during 2017-18, 2018-19 and pooled analysis, respectively), plant spread (94.44, 96.65 and 95.70 cm during 2017-18, 2018-19 and pooled analysis, respectively) and minimum stalk length (6.53, 9.04 and 7.78 cm during 2017-18, 2018-19 and pooled analysis, respectively) were observed with application of (T_{13}) B-20 @ 0.075% + Mo @ 0.45% which was statistically at par with (T_{16}) B-20 @ 0.100% + Mo @ 0.45%, (T_{15}) B-20 @ 0.100% + Mo @ 0.30%, (T_{14}) B-20 @ 0.100% + Mo @ 0.15% and (T_{12}) B-20 @ 0.075% + Mo @ 0.30% during both the years as well as pooled analysis. However, least value of all growth characters was observed with (T_1) control.

Keywords: Cabbage, characters, micronutrients and pooled

Introduction
Vegetables are protective foods, providing vitamins, minerals, proteins, carbohydrates and fibre in the diet besides having medicinal value and provide nutritional security. India ranks second (next to china) in vegetables production with 2.8 per cent of total cropped area under vegetable crops, contributing about 13.88 per cent to world production (FAO, 2017) [3]. Cole-crops are one of the most significant vegetable crops that are widely grown during the winter season in India. Cabbage is an excellent source of vitamin C, potassium and calcium (Hasan and Solaiman, 2012) [5]. It has cooling effect and helps in preventing constipation, increase appetite, speed up digestion and very useful for the patients of diabetes (Yadav, 2000) [10]. It has been reported that 100 g of green edible portion of cabbage contain 92% water, 18 mg Sodium, 170 mg Potassium, 1.28 g Protein, 5.8 g Carbohydrate, 4% Calcium and 2% mg Iron.
Deficiency of 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 (cabbage). Now days, it is realized that foliar spray of micronutrients (Fe, Zn, Mn, B, Mo) has proved beneficial to increase yield, quality and improving shelf life of cabbage (Kotecha *et al*., 2011) [6]. Foliar application of micronutrients can be considered one of the easier and effective methods, to deliver the needed nutrients to plants in adequate concentrations. To overcome the micro nutrient deficiency and to improve the productivity and quality, there is an urgent need to study the effectiveness of micronutrients in cabbage. However, information regarding micro nutrients for cabbage 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 cabbage.

Materials and Methods
An experiment was conducted during two successive winter season of 2017-18 and 2018-19, at Vegetable Research Farm (South Block), Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (situated at 25°10' N latitude and 83°03' 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) B-20 (Boron) @ 0.050%, (T_3) B-20 (Boron) @ 0.075%, (T_4) B-20 (Boron) @ 0.100%, (T_5) Ammonium Molybdate (Mo) @ 0.15%, (T_6) Ammonium Molybdate (Mo) @ 0.30%, (T_7) Ammonium Molybdate (Mo) @ 0.45%, (T_8) B-20 @ 0.050% + Mo @ 0.15%, (T_9) B-20 @ 0.050% + Mo @ 0.30%, (T_{10}) B-20 @ 0.050% + Mo @ 0.45%, (T_{11}) B-20 @ 0.075% + Mo @ 0.15%, (T_{12}) B-20 @ 0.075% + Mo @ 0.30%, (T_{13}) B-20 @ 0.075% + Mo @ 0.45%, (T_{14}) B-20 @ 0.100% + Mo @ 0.15%, (T_{15}) B-20 @ 0.100% + Mo @ 0.30% and (T_{16}) B-20 @ 0.100% + Mo @ 0.45%. Application of Zn 0.5 g l^{-1} was also applied equal in all the treatments involving Goldean Acre variety of cabbage. The crop was transplanted in the 2nd week of October in main field during both the years. The foliar spray was applied at 15, 30 and 45 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) [4]. 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 growth characters of cabbage are presented in Table 1-3. Data indicated that among the treatments, highest plant height at harvest (35.28, 37.67 and 36.47 cm during 2017-18, 2018-19 and pooled analysis, respectively) was observed with application of (T_{13}) B-20 @ 0.075% + Mo @ 0.45% which was statistically at par with (T_{16}) B-20 @ 0.100% + Mo @ 0.45%, (T_{15}) B-20 @ 0.100% + Mo @ 0.30% and (T_{12}) B-20 @ 0.075% + Mo @ 0.30% during both the years as well as pooled analysis. However, least plant height was observed with (T_1) control. Increase in plant height may be due to involvement of zinc, boron and molybdenum in cell division and meristematic growth of the tissue. Similar findings were reported by Pawar and Tambe (2016) [7]. Zn, Mo and Boron reported to improve the plant height of cabbage. Similar result was observed by Agarwal and Ahmed (2007) [1].

Table 1: Effect of micronutrients on plant height (cm) of cabbage at harvest

Notation	Treatments	Plant height (cm) at harvest stage		
		2017-18	2018-19	Pooled
T_1	Control	29.30	31.33	30.32
T_2	B-20 (Boron) @ 0.050%	28.33	34.00	31.17
T_3	B-20 (Boron) @ 0.075%	32.00	34.51	33.26
T_4	B-20 (Boron) @ 0.100%	32.20	34.71	33.46
T_5	Ammonium Molybdate (Mo) @ 0.15%	30.97	33.48	32.22
T_6	Ammonium Molybdate (Mo) @ 0.30%	31.53	34.05	32.79
T_7	Ammonium Molybdate (Mo) @ 0.45%	31.70	34.21	32.96
T_8	B-20 @ 0.050% + Mo @ 0.15%	32.30	34.81	33.56
T_9	B-20 @ 0.050%+ Mo @ 0.30%	32.33	34.92	33.62
T_{10}	B-20 @ 0.050%+ Mo @ 0.45%	32.37	34.88	33.62
T_{11}	B-20 @ 0.075% + Mo @ 0.15%	32.53	35.05	33.79
T_{12}	B-20 @ 0.075% + Mo @ 0.30%	33.07	35.58	34.32
T_{13}	B-20 @ 0.075% + Mo @ 0.45%	35.28	37.67	36.47
T_{14}	B-20 @ 0.100% + Mo @ 0.15%	32.57	35.08	33.82
T_{15}	B-20 @ 0.100% + Mo @ 0.30%	33.30	35.81	34.56
T_{16}	B-20 @ 0.100% + Mo @ 0.45%	33.47	35.98	34.72
S.Em±		0.82	0.87	0.85
LSD (*P*=0.05)		2.46	2.61	2.54

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

Data enumerated in Table 2 varied significantly for micronutrients in respect to plant spread of cabbage for both the years. Scrutiny of data revealed that, application of (T_{13}) B-20 @ 0.075% + Mo @ 0.45% recorded significantly higher plant spread (94.44, 96.65 and 95.70 cm during 2017-18, 2018-19 and pooled analysis, respectively) which was statistically at par with application of (T_{16}) B-20 @ 0.100% + Mo @ 0.45% (93.69 cm) than rest of the treatments during both the years as well as pooled analysis. Whereas, least plant spread at harvest was found with control (T_1) during course of investigation. This might be due to adequate supply of available micronutrients, comparatively less retention in the roots, more translocation to aerial parts for synthesis of protoplasmic proteins and other metabolites enabling the expansion of photosynthetic area, hence the increased plant spread. Application of Zinc @ 0.5% as Zn is important for the formation and activity of chlorophyll, in the functioning of several enzymes and the growth hormone like auxin. However, the auxin availability to the plant might have increased the inter-nodal length coupled with more apical dominance which helped for maximum plant spread. The results are in accordance with the earlier findings of Rajawat (2011) [8] in the cabbage and Singh *et al.* (2018) [9] in broccoli.

Table 2: Effect of micronutrients on plant spread (cm) of cabbage at harvest

Notation	Treatments	Plant spread (cm) at harvest stage		
		2017-18	2018-19	Pooled
T_1	Control	85.00	88.21	86.61
T_2	B-20 (Boron) @ 0.050%	86.64	89.15	87.90
T_3	B-20 (Boron) @ 0.075%	88.15	90.67	89.41

T_4	B-20 (Boron) @ 0.100%	89.22	91.74	90.48
T_5	Ammonium Molybdate (Mo) @ 0.15%	86.00	88.52	87.26
T_6	Ammonium Molybdate (Mo) @ 0.30%	86.30	88.81	87.56
T_7	Ammonium Molybdate (Mo) @ 0.45%	87.34	89.85	88.60
T_8	B-20 @ 0.050% + Mo @ 0.15%	89.83	92.34	91.08
T_9	B-20 @ 0.050%+ Mo @ 0.30%	90.59	93.10	91.84
T_{10}	B-20 @ 0.050%+ Mo @ 0.45%	90.92	93.44	92.18
T_{11}	B-20 @ 0.075% + Mo @ 0.15%	91.34	93.85	92.59
T_{12}	B-20 @ 0.075% + Mo @ 0.30%	93.08	95.59	94.34
T_{13}	B-20 @ 0.075% + Mo @ 0.45%	94.44	96.95	95.70
T_{14}	B-20 @ 0.100% + Mo @ 0.15%	92.52	95.03	93.77
T_{15}	B-20 @ 0.100% + Mo @ 0.30%	93.12	95.64	94.38
T_{16}	B-20 @ 0.100% + Mo @ 0.45%	93.69	96.21	94.95
S.Em±		0.27	0.29	0.27
LSD (*P*=0.05)		0.78	0.84	0.79

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

A cursory glance of Table 3 revealed that micronutrients had significant effect on stalk length of cabbage during both the years of study. Minimum stalk length is the desirable growth character for cabbage. The minimum stalk length (5.00, 7.00 and 6.00 cm during 2017-18, 2018-19 and pooled analysis, respectively) was recorded in (T_1) control and (T_6) Ammonium Molybdate (Mo) @ 0.30% treatment while, maximum stalk length was recorded in treatment T_{13} with the application of B-20 @ 0.075% + Mo @ 0.45%. This increase in growth parameter is due to role of zinc in chlorophyll formation, which has also influenced cell division, meristemic activity of plant tissue and expansion of cells and formation of cell wall by active synthesis of aromatic amino acid *i.e.* tryptophane, which is the primary precursor of auxin and stimulate the growth of plant tissues by cell elongation and cell division. The results are in accordance with the findings of Chaudhari *et al.* (2017) [2] in cabbage and Singh *et al.* (2018) [9] in broccoli.

Table 3: Effect of micronutrients on stalk length (cm) of cabbage

Notation	Treatments	Stalk length (cm)		
		2017-18	2018-19	Pooled
T_1	Control	5.00	7.00	6.00
T_2	B-20 (Boron) @ 0.050%	5.08	7.59	6.34
T_3	B-20 (Boron) @ 0.075%	5.29	7.77	6.53
T_4	B-20 (Boron) @ 0.100%	5.45	7.96	6.70
T_5	Ammonium Molybdate (Mo) @ 0.15%	5.96	7.54	6.25
T_6	Ammonium Molybdate (Mo) @ 0.30%	5.00	7.52	6.26
T_7	Ammonium Molybdate (Mo) @ 0.45%	5.15	7.67	6.41
T_8	B-20 @ 0.050% + Mo @ 0.15%	5.49	8.00	6.74
T_9	B-20 @ 0.050%+ Mo @ 0.30%	5.67	8.19	6.93
T_{10}	B-20 @ 0.050%+ Mo @ 0.45%	5.81	8.32	7.06
T_{11}	B-20 @ 0.075% + Mo @ 0.15%	5.93	8.45	7.19
T_{12}	B-20 @ 0.075% + Mo @ 0.30%	6.03	8.55	7.29
T_{13}	B-20 @ 0.075% + Mo @ 0.45%	6.53	9.04	7.78
T_{14}	B-20 @ 0.100% + Mo @ 0.15%	5.94	8.45	7.20
T_{15}	B-20 @ 0.100% + Mo @ 0.30%	6.12	8.63	7.38
T_{16}	B-20 @ 0.100% + Mo @ 0.45%	6.49	9.01	7.75
S.Em±		0.22	0.32	0.27
LSD (*P*=0.05)		0.64	0.93	0.78

**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, plant spread and minimum stalk length of cabbage was recorded with application of (T_{13}) B-20 @ 0.075% + Mo @ 0.45% which was statistically at par with application of (T_{16}) B-20 @ 0.100% + Mo @ 0.45% (93.69 cm) than rest of the treatments during both the years as well as pooled analysis.

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