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Effect of foliar spray of micronutrients on growth and yield of cauliflower (*Brassica oleracea* L. var. Botrytis)

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Abstract
The experiment was conducted during *rabi*, 2016-2017 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari, Gujarat, India. The experiment was arranged over 9 treatments comprising, micronutrient sources which was laid out in a Randomized Block Design with three replications.
The application of 1% General grade-1 + T1 had shown significant impact on growth parameters viz. plant height (74.93 cm), Length of stalk (16.59 cm), Number of leaves per plant (23.39) and Plant spread (N-S: 76.81 cm & E-W: 77.79 cm) at harvest. Highest marketable curd yield per plot (37.11 kg), marketable curd yield per hectare (28.64 t) and other yield attributes viz. curd diameter (19.16 cm), Gross weight of curd (2.65 kg/plant) and Net weight of curd (883.33 g/plant) were recorded significantly highest in T8 treatment. While days of first curd initiation and days to first marketable curd did not show any significant differences.

Keywords: Cauliflower, growth, micronutrients, yield

Introduction
Cauliflower (Brassica oleracea L. var. Botrytis) belongs to family Brassicaceae, is one of the most important winter vegetables grown in India. It is a European origin probably developed from broccoli (Swaroop and Chatterjee, 1972) [14]. Cauliflower [Brassica oleracea (L.) var. botrytis] is the most popular winter vegetable among cole crops. It is propagated through seed and healthy seedling is important to raise a good crop. The edible part, i.e. curd is a 'prefloral fleshy apical meristem' and it is generally white in colour and may be enclosed by inner leaves before its exposure. Adopting various improved agro-techniques can enhance the productivity of cauliflower.
The micronutrients though required in small quantities are as important as macronutrients. The role of micronutrients in regulation plant growth and yield is established. Different micronutrients have specific role in cauliflower production. Micronutrients although required in trace amount, play vital role in completion of life cycle of this crop. Among all (Boron, Molybdenum, Iron, Copper, Chlorine, Zinc and Manganese), Boron and Molybdenum are more important than others due to its availability in soil, mobility in plants and soil and more dependency upon pH in soil.

Materials and Methods
The experiment was carried out at Regional Horticultural Research Station (RHRS), ASPEE College of Horticulture and Forestry (ACHF), Navsari Agricultural University, Navsari, Gujarat during *rabi*, 2016-17 in cauliflower cv. Snowball-16. The experiment was planned with nine treatments *viz.*, 0.1% Ammonium molybdate (T_1), 0.2% Boric acid (T_2), 0.5% Zinc sulphate (T_3), 0.5% Copper sulphate (T_4), 0.5% Ferrous sulphate (T_5), 0.5% Manganese sulphate (T_6), 1% General grade-1 (T_7), 1% General grade-1+ Ammonium molybdate (T_8) and Control (T_9) in a Randomized Block Design (RBD) with three replications. Cauliflower plants were grown at the spacing of 60 x 45 cm and fertigated with recommended dose of FYM 20 t/ha at the time of land preparation and fertilizers N:P:K at the rate of 125: 80: 60 kg/ha at the time of planting. Two spray of each treatment were made during cropping season of cauliflower, first at the 45 DAT and second at 60 DAT. Plants in control plots were sprayed with ordinary water.

The data were taken from randomly selected five plants from each plot on various characters *viz*., plant height at harvest (cm), length of stalk (cm), number of leaves per plant, plant spread (N-S&E-W), days of first curd initiation, days to first marketable curd, curd diameter (cm), gross weight of curd (kg/plant), net weight of curd (g/plant), yield of curd per plot (kg) and yield of curd per hectare (t).

Results and Discussion

The Effect of foliar spray of Micronutrients on Growth and yield of Cauliflower (Brassica oleracea L. var. Botrytis) cv. Snowball-16 is presented as mean values with statistical notation in the different tables.

Growth Parameters

The results of various growth parameters namely plant height, length of stalk, number of leaves, plant spread, days of first curd initiation and days to first marketable curd as influenced by foliar application of micronutrients in cauliflower are presented in Table 1. The micronutrients influenced plant height, length of stalk, number of leaves, plant spread (N-S&E-W) significantly throughout the growing season of cauliflower to the highest level of 74.93 cm, 16.59 cm, 23.39, and 76.81 cm & 77.79 cm respectively at harvest stage, which were at par with treatment T_7 (General grade-1+T_1). The effect of foliar spray of micronutrient was found to be non-significant for days to first curd initiation and days taken to marketable yield.

Yield Parameters

The results on effect of foliar application of micronutrients on various yield and attributes *viz.*, curd diameter, gross weight of curd, net weight of curd, yield of curd per plot and yield of curd per hectare in cauliflower as influenced by foliar application of micronutrients are presented in Table 2. The maximum diameter of curd (19.16 cm) was recorded in T_8 (1% General grade-1+T_1) followed by T_7 treatment. The Treatment T_8 noticed highest gross weight of curd (2.65 kg/plant) which was at par with T_2 (2.23 kg/plant) and T_7 (2.46 kg/plant). The treatment T8 produced significantly maximum net weight of curd per plant (883.33 g), which was at par with T2 (811.67 g/plant), T3 (807.00 g/plant) and T7 (860.67 g/plant). Among various treatments, T8 (1% General grade-1+T1) recorded maximum curd yield per plot and yield of curd per hectare 37.11 kg and 28.64 t, respectively which was statistically at par with T2 (34.97 kg and 26.99 t), T3 (33.39 kg and 25.77 t) and T7 (36.16 kg and 27.90 t) respectively.

Increase in plant height and length of stalk is a good indicator of plant growth. This increase in vegetative growth might be due to the role of zinc activates in chlorophyll formation, it also influenced the cell division, meristematic activity of plant tissues and expansion of cell and formation of cell wall by active synthesis of aromatic amino acid i.e., tryptophan, which is precursor of IAA and it is responsible to stimulate plant growth by cell elongation and cell division (Choudhary and Mukherjee, 1999) [2], Sharma *et al*. (2005) [13] in cabbage, Kanujia *et al.* (2006) [7] observed in cauliflower and also substantiated similar trends of increase in vegetative growth during their period of study. Iron plays an important role in promoting growth characters, being a component of ferredoxin, an electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better vegetative growth (Hazra *et al.* 1987) [6].

The occurrence of higher curd diameter upon T_8 treatment was combination of Fe, Mn, Zn, Cu and B, which is the best for production of highest diameter of curd. This could be due to the application of micronutrient induced the synthesis of chlorophyll which in turn resulted in higher vegetative growth. This is in accordance with Narayanamma *et al.* (2007) [12], Yadav *et al*. (2009) [15], Kotecha *et al.* (2011) [8] in cabbage. Zinc increases curd diameter and curd weight due to the improved physiological activities like photosynthesis during which food is manufactured by the plant translocation of assimilates from leaves to curd and their storage in curd for which zinc was a responsible factor (Lashkari *et al.* 2008) [9]. Improvement in yield characters as a result of foliar application of micronutrients might be due to the enhancement in photosynthesis and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation (Hatwar *et al.* 2003) [5]. Molybdenum had significant effect on yield characters may be due to the increase of the estimated attributed in leaves. In addition, the promotion in plant weight reflected in a significant increase of curd yield. Furthermore the stimulatory effect of molybdenum application could be due to the increase of the metabolic pools required for the synthesis of saccharides, along with the enhanced photosynthetic capacity (Mohamed El-Sayed Ahmed *et al.* 2011) [1]. The higher curd yield may be due to synergetic interaction effect between applied boron and phosphorous in the plant (Dhakal *et al.* 2009) [4]. The synergetic effect of Zn with P which may serve as a source of energy for the synthesis of auxin in the presence of Zn. Enhanced photosynthetic reaction in the presence of zinc and boron was also reported by Mallick and Muthukrishnan (1980) [10].

Conclusion

The result inferred that the foliar spray of micronutrients of 1% General grade-1 (Fe-2.0, Mn-0.5, Zn-4.0, Cu-0.3 and B-0.5) +T_1 (Ammonium molybdate) is favorably influenced plant growth and yield attributes. Results clearly emphasized the importance of foliar spray of micronutrients for higher yield produce hence, gave a remunerative return. Based on the trend of curd yield and economical aspect of cauliflower observed in the present study; it is concluded that for getting higher yield of cauliflower curd treatment (T_8) *i.e*. General grade-1 + T_1 two spray of micronutrients at 45 days after transplanting and 60 days after transplanting was found better

Table 1: Effect of foliar spray of Micronutrients on growth and growth parameters of cauliflower

Treatments	Plant height (cm)	Length of stalk (cm)	No. of leaves per plant	Plant spread (cm)		Days of first curd initiation	Days to first marketable curd
				N-S	E-W		
T_1: Ammonium molybdate (0.1%)	63.54	14.34	19.68	73.74	65.75	57.93	91.03
T_2: Boric acid (0.2%)	79.54	15.21	22.02	74.08	70.87	57.60	90.53
T_3: Zinc sulphate (0.5%)	65.70	15.07	20.53	71.28	72.21	60.00	91.93
T_4: Copper sulphate (0.5%)	58.29	13.94	18.44	64.03	63.10	58.13	92.90
T_5: Ferrous sulphate (0.5%)	61.74	14.33	19.80	67.37	65.88	59.07	90.87

T_6: Manganese sulphate (0.5%)	62.53	14.08	19.68	72.85	63.22	60.13	93.13
T_7: General grade-1 (1%)	70.92	15.24	22.77	74.95	74.64	59.93	91.33
T_8: 1% General grade-1+T_1	74.93	16.59	23.39	76.81	77.79	58.47	89.96
T_9: Control	58.14	12.40	16.54	60.69	57.29	60.27	94.30
S.E.m. ±	3.559	0.695	1.148	3.364	3.954	1.339	3.645
$C.D._{0.05}$	10.67	2.08	3.44	10.08	11.85	NS	NS
C.V. %	9.48	8.26	9.79	8.25	10.09	3.93	6.88

Table 2: Effect of foliar spray of micronutrients on yield and yield parameter of cauliflower

Treatments	Curd diameter (cm)	Gross weight of curd (kg/plant)	Net weight of curd (g/plant)	Yield of curd per plot (kg)	Yield of curd per hectare (t)
T_1: Ammonium molybdate (0.1%)	16.31	2.10	725.00	30.24	23.34
T_2: Boric acid (0.2%)	17.15	2.23	811.67	34.97	26.99
T_3: Zinc sulphate (0.5%)	17.14	2.11	807.00	33.39	25.77
T_4: Copper sulphate (0.5%)	14.90	2.02	719.67	29.67	22.90
T_5: Ferrous sulphate (0.5%)	16.19	2.07	726.67	30.04	23.18
T_6: Manganese sulphate (0.5%)	16.12	2.04	732.00	30.57	23.59
T_7: General grade-1 (1%)	18.00	2.46	860.67	36.16	27.90
T_8: 1% General grade-1+T_1	19.16	2.65	883.33	37.11	28.64
T_9: Control	14.01	1.95	668.67	27.24	21.02
S.E.m. ±	0.953	0.143	44.872	2.063	1.591
$C.D._{0.05}$	2.86	0.43	134.51	6.18	4.77
C.V. %	9.97	11.34	10.09	11.11	11.11

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