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Effect of boron and molybdenum on growth and yield on cauliflower (*Brassica oleracea var. botrytis* L.) CV. snowball-16 at different stage

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Abstract
The present investigation was carried out to study the, "Effect of micronutrients on growth and yield of cauliflower (*Brassica oleracea var. botrytis* L.) cv. Snowball-16" was carried out at Horticulture farm of Udai Pratap Autonomous College, Varanasi during 2018-2019 in winter season. The experiment was conducted with 12 treatments of boron in Randomized Block Design with three replications. The plot size was 1.5 m × 1.2 m with spacing of 45 cm × 45 cm. Each plot consisted of 3 rows with 3 plants. Each replication was comprised of 12 treatments are T_1 (Control), T_2 (Foliar application of Ammonium molybdate @ 0.1%), T_3 (Foliar application of Ammonium molybdate @ 0.2%), T_4 (Foliar application of Ammonium molybdate @ 0.3%), T_5 (Foliar application of Borax @ 0.25%), T_6 (Foliar application of Borax @ 0.50%), T_7 (Foliar application of Borax @ 0.23% + Ammonium molybdate @ 0.1%), T_8 (Foliar application of Borax @ 0.25% + Ammonium molybdate @ 0.2%), T_9 (Foliar application of Borax @ 0.25% + Ammonium molybdate @ 0.3%), T_{10} (Foliar application of Borax @ 0.50% + Ammonium molybdate @ 0.1%), T_{11} (Foliar application of Borax @ 0.50% + Ammonium molybdate @ 0.2%), T_{12} (Foliar application of Borax 0.50% + Ammonium molybdate @ 0.3%). Foliar application of Borax @ 0.50% and Ammonium molybdate @ 0.1%(T10) are most effective for highest growth and yield of cauliflower (*Brassica oleracea var. botrytis* L.) comparison to other treatments as well as control. This in general, may be adopted for profitable cultivation of cauliflower crop under the agro-climatic condition of Varanasi region.

Keywords: cauliflower, boron, molybdenum, growth and yield

Introduction
India is the largest producer of cauliflower in the world. In India, cauliflower is grown in an area of 452.6 thousand hectare, production 8668.2 thousand MT and productivity is 19.2 MT per hectare. In Utter Pradesh the annual production of cauliflower is 400.81 thousand MT, in an area of 17.53 thousand hectare with productivity 16 MT per hectare. West Bengal is largest producer 0f cauliflower in India (Horticulture Statistics, Ministry of Agriculture & Farmers Welfare, 2017-18).

Cauliflower grown in all types of soil with good soil fertility and good drainage system, because of over mining of the plant food elements by the crops most of the micronutrient become in short supply to the crops and some disorders appear resulting in low yield (Joshi 1997) [14]. Some of the micronutrients required by the cauliflower crop become unavailable if the soil condition is acidic, such as molybdenum, in cauliflower boron deficiency has been reported very frequently (Som and Maity). The cauliflower crop often shows the deficiency symptoms of boron and molybdenum as browning of curd and whiptail curd formation of leaves respectively. These disorder render curds unit for human consumption and reduce the curd yield considerably; (Singh and Thakur, 1991) [21].

Cauliflower responds severally to the deficiency of molybdenum and the damage may be considerable. Young cauliflower plants in a shortage of this element become chloratic and may turn white, particularly along the leaf margins; they also become cupped and wither. Eventually, the leaf dies and the growing point also collapses. In older plants, the laminas of the newly formed leaves are irregular in shape, frequently consisting of only a large bare midrib and hence the common name 'whiptail' originated. According to Agarwal (1950) [5], the nitrogen deficiency not only results in buttoning but it also develops the deficiency symptoms of molybdenum. The whiptail develops with high nitrate supply and low molybdenum (Agrawal and Hewitt, 1954) [6].

Since cauliflower has high nitrogen requirement, it may be useful to ensure an adequate supply of molybdenum to avoid whiptail. The experiment was conducted at department of horticulture farm, Udai Pratap Autonomous College, Varanasi (Utter Pradesh) during Rabi season 2018-19. Each replication was comprised of 12 treatments are T_1 (Control), T_2 (Foliar application of Ammonium molybdate @ 0.1%), T_3 (Foliar application of Ammonium molybdate @ 0.2%), T_4 (Foliar application of Ammonium molybdate @ 0.3%), T_5 (Foliar application of Borax @ 0.25%), T_6 (Foliar application of Borax @ 0.50%), T_7 (Foliar application of Borax @ 0.23% + Ammonium molybdate @ 0.1%), T_8 (Foliar application of Borax @ 0.25% + Ammonium molybdate @ 0.2%), T_9 (Foliar application of Borax @ 0.25% + Ammonium molybdate @ 0.3%), T_{10} (Foliar application of Borax @ 0.50% + Ammonium molybdate @ 0.1%), T_{11} (Foliar application of Borax @ 0.50% + Ammonium molybdate @ 0.2%), T_{12} (Foliar application of Borax 0.50% + Ammonium molybdate @ 0.3%).The experiment was conducted with 12 treatments of boron and molybdenum in Randomized Block Design with three replications. The plot size was 1.5 m × 1.2 m with spacing of 45 cm × 45 cm. Each plot consisted of 3 rows with 3 plants Five plants in each treatment and in each replication (except border row and border plants) were selected randomly, numbered, tagged properly for detailed studies at 30 days interval at vegetative stage after transplanting and then at harvesting time. The data were recorded as per standard procedure and listed as under. Plant height (cm), Number of leaves per plant, Leaf length (cm), Leaf width (cm), Stalk/stem length (cm), Days to curd initiation, Days to curd maturity, Curd diameter (cm), Gross plant weight (g), Gross plant weight (g), Marketable curd weight (g), Net curd weight (g), Yield per plot (kg) and Yield (q/ha)

Results and Discussion

The observations were recorded in respect of influence of different micronutrients on growth and yield and attributes of cauliflower and were analysed statistically and the results obtained are presented in this chapter. The data was statistically analysedas per Randomized Block Design (RBD) and the "ANOVA" tables are given in appendix.

Table 1: Mean values for growth and yield parameters of cauliflower cv. snowball-16.

Treatments	Plant height (cm)	Number of leaves per plant	Stalk/stem length (cm)	Curd diameter (cm)	Gross plant weight (g)	Net curd weight (g),	Yield per plot (kg)	Yield (q/ha)
Normal Tillage (B_1)								
T1	28.56	11.31	5.22	15.13	1552.70	588.00	2.62	154.53
T2	29.17	11.74	5.65	16.23	1787.32	816.20	3.62	201.36
T3	30.82	12.38	6.21	17.52	2039.44	923.96	3.96	219.98
T4	29.96	11.93	5.88	16.93	1911.36	897.83	3.69	204.80
T5	30.28	12.04	6.02	17.41	2031.63	907.50	5.05	225.09
T6	30.60	12.60	6.19	18.15	2158.62	1051.50	4.18	232.20
T7	31.70	12.98	6.39	17.42	2327.44	1052.30	4.53	251.60
T8	29.08	11.56	6.69	16.13	1758.92	763.30	3.40	188.76
T9	30.48	12.01	6.00	17.23	1911.22	905.60	3.78	210.20
T10	32.96	12.92	6.97	18.40	2541.13	1200.00	4.87	270.60
T11	31.32	12.60	6.25	17.37	2070.98	1013.30	4.21	233.70
T12	29.53	11.84	5.70	16.48	1991.22	865.30	3.52	199.06
CD- 5%	0.755	0.643	0.521	0.705	2.012	1.709	0.601	3.240

All the treatments were found significantly improve the growth and yield parameters in terms of the plant height, number of leaves per plant, stalk depth per plant, curd diameter, gross plant weight, net curd weight, yield per plot and yield (q/ha). Similar findings were also reported by Ahmadvand *et al.* (2012, sunflower) [7], Farooq *et al.* (2006, rice) [9], Monel *et al.* (2011, sorghum), Patel *et al.* (2017, maize) [18] and Singh *et al.* (2017, wheat).

Among the treatments, T_{10}(Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray) resulted in significant tallest plant over all the growth stages, however it was found statistically at par with T_3,T_4, T_5,T_6, T_7,T_9 and T_{11} at 30DAT, T_7 and T_{11} at 60 DAT and at harvesting. While, it was minimum in control (T_1). Similar results were also found by Ajirloo *et al.* (2013, maize) [8], Farooq *et al.* (2006, rice) [9], Jafar *et al.* (2012, wheat), Pawar *et al.* (2003, sunflower), Shehzad *et al.* (2012, sorghum).

The results revealed that, the maximum number of leaves per plant of cauliflower at 30 DAT, 60 DAT and at harvesting stage were recorded (11.78, 13.1 and 12.92 respectively) in treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray) and which was statistically at par with treatment T_3, T_6 and T_7. However, minimum number of leaves per plant (9.5, 11.29 and 11.31 respectively) at30 DAT, 60 DAT and at harvesting stage were found**.** These findings were strongly supported by Ajirloo *et al.* (2013, maize) [8], Meena *et al.* (2013, wheat), Toklu *et al.* (2015, wheat) [24], Patel *et al.* (2017, brinjal & tomato) [18], Yucel *et al.* (2012, lentil) [25].

The stalk depth per plant increased significantly by the different treatments of boron and molybdenum. The highest stalk depth per plant (6.97 cm) was found in treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray), which was at par with treatment T_7 and T_{11}. Whereas, the lowest stalk depth per plant (5.22 cm) was observed in treatment T_1 (control). Similar finding reported by Kathiresan *et al.* (1984, sunflower) [15], Farooq *et al.* (2006, rice) [9], Afzal *et al.* (2007, wheat) [4], Abbasdokht *et al.* (2010, wheat) [1], Hanegave *et al.* (2011, maize) [12] and Singh *et al.* (2017, wheat).It is obvious from Table 1 that the average curd width was significantly influenced by the different treatments of boron and molybdenum. Treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray), was observed highest curd width (18.40 cm), which was statistically at par with T_3, T_5, T_6, T_7 and T_{11}.Whereas, the lowest curd width (15.13 cm) was found in the treatment T_1 (Control).

Significantly increased in the gross plant weight was observed due to different treatments of boron and molybdenum. Treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray), was observed highest gross plant weight (2541.13 g)followed by T_3,T_6, T_7 and T_{11}.Whereas, the lowest gross plant weight (1552.70 g) was found in the treatment T_1 (Control).

It is obvious from Table 1 that the average net curd weight was significantly influenced by the different treatments of boron and molybdenum. Treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray) recorded maximum net curd weight (1200.00 g) followed by T_3, T_6, T_7 and T_{11}. Whereas, minimum net curd weight (588.00 g) was found in the treatment T_1 (Control) andthe yield per plot was significantly influenced due to various treatments of boron and molybdenum. The treatment T_{10} (Borax @ 0.5% + Ammonium molybdate @0.1% as foliar spray), was found superior (4.87 kg) followed by T_5, T_6, T_7 and T_{11}. Whereas, yield per plot(2.62 kg) was found in the treatment T_1 (Control).

The yield per of any crop is the final index of the experiment which indicates the success or failure of any treatment with this view the curd yield of cauliflower was recorded. The data for the yield per plot under different treatments were recorded and converted into yield q/ha. These findings were strongly supported by Farooq *et al.* (2008) [10] Ghobadi *et al.* (2011) [11], Toklu *et al.* (2015) [24] in wheat, Derya Ozveren Yucel *et al.* (2012) [25] in lentil, Adinde *et al.* (2016) [3] in green pepper, Patel *et al.* (2017) [18] in brinjal & tomato.

Conclusion

On the basis of experimental evidences, it is concluded that the of cauliflwoer cv. Snowball-16respond well in terms of growth and yield to application of boron and comparison to other treatments as well as control. This in general, may be adopted for profitable cultivation of cauliflower crop under the agro-climatic condition of Varanasi region. molybdenum.

Foliar application of Borax @ 0.50% and Ammonium molybdate @ 0.1% are most effective for highest growth and yield of cauliflower (*Brassica oleracea var. botrytis* L.)

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