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Effect of boron and molybdenum on growth, yield and quality of cauliflower (*Brassica oleracea* var *botrytis*) cv. Snowball 16

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Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most popular cruciferous vegetables. This crop often shows the deficiency symptoms of boron and molybdenum as browning of curd and whiptail disorder, respectively. These disorders render curds unfit, for human consumption and reduce the curd yield considerably. Cauliflower responds well to macro nutrients–nitrogen, phosphorus and potassium. However, micro–nutrients are also essential for its proper growth and yield especially boron, molybdenum, iron, etc. The response to the foliar application of micronutrients has been very spectacular as they play important role in flowering and fruiting processes, pollen germination, cell division and metabolism of carbohydrates. Due to boron deficiency water soaked areas appear on the stem and head surface, gradually the stem becomes hollow and curd turns brown. Again the molybdenum deficiency appears on young plant with chlorosis of leaf margins and gradually the whole leaf turns white. As a result the leaf blade fails to develop properly and only the midrib portions develop resulting sword like appearance of leaves giving whiptail symptom. Besides, the quantity of boron and molybdenum depend on soil type, soil reaction and the extent of deficiency (Lal 1993). Keeping in view, the importance of micronutrients in cauliflower the present investigation was carried out to find out effect of boron and molybdenum in cauliflower for growth, yield and quality of cauliflower in Kymore Plateau of Madhya Pradesh.

A field experiment was conducted in the experimental field of Department of Horticulture, College of Agriculture, Rewa under Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during the *rabi* season 2009-2010. The soil of experimental site was mixed red black with clay loam in texture and having depth of 4. The pH of soil was 7.23 and available nutrients were, nitrogen (288.75 kg/ha), phosphorous (19.71 kg/ha) and potassium (288.4 kg/ha). The experiment was carried out in randomized block design with four replications using Snowball-16 variety. The treatment combinations consist of T_1 (Control), T_2 (Borax @ 100 ppm as foliar spray), T_3 (Ammonium molybdate @ 50 ppm as foliar spray), T_4 (Borax @ 100 ppm + ammonium molybdate @ 50 ppm as foliar spray), T_5 (Borax @ 10 kg/ha as soil application), T_6 (Borax@ 20 kg/ha as soil application), T_7 (Ammonium molybdate @ 1 kg/ha as soil application), T_8 (Ammonium molybdate @ 2 kg/ha as soil application), T_9 (Borax @ 10 kg/ha + ammonium molybdate @ 1 kg/ha as soil application), T_{10} (Borax @ 10 kg/ha + ammonium molybdate @ 2 kg/ha as soil application), T_{11} (Borax @ 20 kg/ha + ammonium molybdate @ 1 kg/ha as soil application) and T_{12} (Borax@ 20 kg/ha + ammonium molybdate@ 1 kg/ha as soil application, Borax contain 11% boron and ammonium molybdate contain 98.99% tracer element). The crop was grown with the recommended dose of N: P: K (100:60:80 kg/ha) and FYM@ 200q/ha. Full dose of phosphorus, potash half dose of nitrogen along with different doses of boron and molybdenum (as per treatments) were applied as soil application before transplanting. The remaining half dose of nitrogen was applied at 30 days after transplanting (DAT) and three consecutive foliar sprays of different doses of boron and molybdenum (as per treatments) was done at 10 days interval starting from 30 DAT. Thirty eight days old healthy and uniform seedlings of cauliflower were transplanted on 24 November 2009 in the experimental field at a spacing of 60 cm × 45 cm. Observations on plant height, number of leaves/plant, length of leaves, width of leaves, stem girth, diameter of curd, fresh weight of curd, yield/plot, yield/ha, grading percentage of curds and dry matter of curd percentage were recorded on plants from each replication. The grading of curd is normally on the basis of visual observations. The data were average and statistically analyzed according to Fisher (1958).

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The growth characters of cauliflower increased significantly with the different levels of boron and molybdenum (Table 1). The significantly superior plant height at 30, 45 and 60 DAT was observed in T_9 treatment, i.e. 24.20 cm, 29.38 cm and 34.35 cm, respectively. Significantly lowest plant height was observed in control (T1) at all growth stages. The remaining treatments were almost identical to each other in influencing the plant height. The results are in close agreement with the findings of Sharma (2002) in cauliflower, who stated that the probable reasons for enhanced plant height and number of leaves, may be due to promotive effects of molybdenum on vegetative growth which ultimately lead to more photosynthetic activities. Similar findings were also reported by Singh and Rajput (1976), Muthoo *et al.* (1987) and Rahman *et al.* (1992). The minimum plant height was observed in control T_1 because deficiency of boron and molybdenum may cause death of growing point due to negative effect on active salt absorption and water relation in plants. The number of leaves/plant increased significantly with the different treatments of boron and molybdenum at every stage of observations. At 30 DAT, the maximum number of leaves per plant (7.86) was noted in treatment T_9, while it was minimum (6.65) in control treatment T_1. At 45 DAT, the treatment T_9 was found significantly superior (11.88) in comparison to the rest of the treatments. Whereas control treatment T_1 was minimum (10.65) for the same characters. At 60 DAT, the highest number of leaves/plant (19.45) was observed in treatment T_9 and the lowest (16.49) was found in control treatment T_1. At 60 DAT stage, the maximum leaf length (32.02 cm) was recorded under treatment T_9 equally followed by treatment T5 (31.07 cm). On the other hand, the minimum leaf length (29.07 cm) was found under control treatment T1. Most of the other treatments were found identical to each other. The similar results trend was observed in case of 30 and 45 DAT stage also. The leaf width was recorded treatment wise at 30, 45 and 60 DAT stages and the mean values are depicted in Table 1 reveals that treatments exhibited significant influence on leaf width at every stage. At 60 DAT stage, the treatment T_9 recorded highest leaf width (28.31 cm) over rest of the treatments, while minimum leaf width (25.72 cm) was observed in control treatment T^1 as well as in T_9. The similar results noted in case of 30 and 45 DAT stages also.

Table 1 Growth characters of cauliflower as influenced by boron and molybdenum treatments

Treatment	Plant height (cm)			Number of leaves/plant			Length of leaves (cm)			Width of leaves (cm)		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
Control (T_1)	22.80	27.85	32.50	6.65	10.65	16.49	14.40	24.25	29.07	14.65	19.77	25.72
Borax @100 ppm as foliar application (T_2)	22.90	27.95	32.68	6.72	10.67	16.76	14.75	25.48	30.19	16.25	21.28	27.27
Amm. Moly. @50ppm as foliar application (T_3)	23.65	28.32	33.67	7.46	11.25	16.80	14.50	25.65	30.31	15.78	20.64	26.68
Borax@100ppm +Amm. Moly. @50ppm as foliar application (T_4)	23.96	28.84	33.81	7.77	11.59	19.18	15.53	26.49	30.53	15.85	20.76	26.66
Borax @10 kg/ha as soil application (T_5)	23.56	28.62	33.53	7.59	11.59	17.79	16.15	26.42	31.07	16.68	21.63	27.71
Borax @20 kg/ha as soil application (T_6)	23.83	28.55	33.58	7.65	11.66	17.89	17.21	26.59	30.80	15.66	20.54	26.57
Amm. Moly. @1 kg/ha as soil application (T_7)	23.81	28.75	33.59	7.75	11.69	18.82	16.37	25.53	30.52	15.61	20.61	26.63
Amm. Moly. @2 kg/ha as soil application (T_8)	23.58	28.54	33.69	7.55	11.57	17.79	17.60	26.54	30.42	15.56	20.52	26.43
Borax @10 kg+ Amm. Moly. @1 kg/ha as soil application) (T_9)	24.20	29.38	34.35	7.86	11.88	19.45	17.80	28.11	32.02	17.37	22.34	28.31
Borax @10 kg+ Amm.Moly. @ 2 kg/ha as soil application (T_{10})	23.91	28.75	33.64	7.81	11.70	18.82	16.58	26.24	30.39	15.53	20.58	26.61
Borax @20 kg+ Amm. Moly. @1 kg/ha as soil application (T_{11})	23.77	28.60	33.98	7.60	11.61	18.50	15.74	26.35	29.85	14.85	19.67	25.74
Borax @20 kg+ Amm. Moly. @2kg/ha as soil application (T_{12})	23.90	28.73	33.94	7.62	11.79	18.54	16.44	25.43	30.15	16.28	21.43	27.39
SEm±	0.136	0.093	0.15	0.08	0.083	0.062	0.116	0.12	0.14	0.087	0.097	0.117
CD (P=0.05)	0.41	0.278	0.45	0.240	0.250	0.187	0.35	0.36	0.42	0.26	0.29	0.35

Moreover, molybdenum is essential for the process of atmospheric 'N'- fixation. It increase 'N'- fixing ability in plants and also helpful for the reduction of nitrates to ammonia prior to amino acid in the cell of the plants. These findings corroborate with their results obtained by Kumar (2004, 2005) and Mahmud *et al.* (2005).

The different treatments exhibited significant impact upon stem girth parameter. Thus the significantly highest stem girth (5.14 cm) was recorded in case of T_9 over rest of the treatments. However, T_{12} also recorded equally higher stem girth (5.12 cm) and then T_5 and T_8 (5.04 to 5.05 cm). This significantly lowest stem girth (4.50 cm) was recorded in control treatment T_1 followed by T_3 (4.71 cm). Similarly, Singh (2003) observed the greatest stem girth with the soil application of borax @ 10 kg/ha. Thus, increase in stem girth could be attributed to the proper proportion of boron and molybdenum content, that gave better results in metabolic functions in plant life and play important roles in both the vegetative as well as reproductive phases.

It is obvious from Table 2 that the average curd diameter significantly influenced by the different treatments of boron and molybdenum. Treatment T_9 recorded the highest curd diameter (18.41 cm) which was statistically *at par* with treatment T_4. The treatment T_{11} was the third best treatment (17.83 cm). On the other hand the lowest curd diameter (15.52 cm) was found in the control treatment T_1. Similar results have been reported by Kotur (1993, 1994), Kumar and Choudhary (2002), Prasad and Yadav (2003), Singh (2003) and Kumar (2004; 2005). While the lowest curd diameter (15.52 cm) was found in the treatment control due to deficient effect of boron and molybdenum. The fresh weight of curd was also influenced significantly due to applied treatments. The treatment T_9 recorded the maximum fresh weight of curd (1.24 kg). This was equally followed by T_2, T_4 and T_{12} treatments (1.13 to 1.14 kg). The treatments T_3 and $T_{11,}$ T_6 and T_7 recorded equal fresh weight of curd (0.93 to 0.96 kg). The significantly lowest fresh weight of curd (0.69 kg) was noted in control treatment T_1. These findings are in confirmation with findings of Sharma *et al.* (1988), Kotur (1993, 1995), Singh *et al.* (2002), Prasad and Yadav (2003), Kumar (2004, 2005) and Mahmud *et al.* (2005). While, the control treatment showed minimum (0.69 kg) for the same character. This could be due to the lack of boron and molybdenum.

The yield/plot was significant, influence, due to various treatments of boron and molybdenum. The treatment T_9 was found significantly superior (17.29 kg) over rest of the treatments, whereas the yield/plot was observed significantly lowest (9.43 kg) in control treatment T_1. The treatments like T_2, T_4 and T_{12} gave the equal values (15.40 to 15.51 kg).

Table 2 Yield and quality parameters of cauliflower as influenced by boron and molybdenum treatments

Treatment	Girth of stem (cm)	Diameter of curd (cm)	Fresh weight of curd (kg)	Yield/ plot (kg)	Yield/ ha (q)	Dry matter of curd (%)	Grading percentage of curd		
							A	B	C
Control (T_1)	4.50	15.52	0.69	9.43	218.28	7.45	46.57	32.24	21.12 (4.65)
Borax @100 ppm as foliar application (T_2)	4.71	17.57	1.14	15.40	356.42	7.61	46.64	33.09	20.01 (4.53)
Amm. Moly. @50ppm as foliar application (T_3)	4.84	17.41	0.93	14.28	330.55	8.37	47.20	33.38	19.42 (4.46)
Borax@100ppm+Amm. Moly.@50ppm as foliar application (T_4)	5.05	17.99	1.13	15.51	358.91	8.44	47.34	33.46	19.17 (4.44)
Borax @10 kg/ha as soil application (T_5)	4.62	16.48	0.79	12.37	286.40	8.75	47.73	34.00	18.26 (4.33)
Borax @20 kg/ha as soil application (T_6)	4.82	17.63	0.96	14.54	336.51	9.29	48.51	34.70	17.30 (4.22)
Amm. Moly. @1 kg/ha as soil application (T_7)	5.04	17.22	0.95	13.45	311.34	9.50	50.11	35.15	15.65 (4.02)
Amm. Moly. @2 kg/ha as soil application (T_8)	4.88	16.59	0.85	13.38	309.66	9.49	52.54	35.20	12.26 (3.57)
Borax @10 kg+ Amm. Moly. @1 kg/ha as soil application (T_9)	5.14	18.41	1.24	17.29	400.29	11.37	49.83	35.25	14.74 (3.90)
Borax @10 kg+ Amm. Moly.@ 2 kg/ha as soil application (T_{10})	4.92	16.26	0.73	11.48	265.74	9.39	47.11	33.35	19.54 (4.48)
Borax @20 kg+ Amm. Moly. @1 kg/ha as soil application (T_{11})	4.92	17.83	0.93	13.73	317.76	9.69	47.37	33.44	19.19 (4.44)
Borax @20 kg+ Amm. Moly. @ 2kg/ha as soil application (T_{12})	5.12	17.22	1.13	15.42	356.88	10.35	47.44	33.46	19.11 (4.43)
SEm±	0.055	0.178	0.048	0.101	2.34	0.673	0.928	0.416	0.397
CD (P=0.05)	0.164	0.534	0.144	0.303	7.021	2.019	2.783	1.249	1.191

Similarly T_7, T_8 and T_{11} were equally effective (13.38 to 13.73 kg). The analysis of variance Table 2 showed that cauliflower yield (q/ha) was significantly affected due to various treatments of boron and molybdenum. The maximum yield/ha (400.29 q/ha) was recorded in treatment T_9 which was followed by treatment T_4 (358.91 q/ha). It was observed that control treatment T_1 had minimum yield (218.28 q/ha). The treatments T_2 and T_{12} also recorded equally higher yield (356.42 to 356.88 q/ha). These findings corroborate with the results obtained by Rahman *et al.* (1992), Singh and Thakur (1999), Sharma (2002), Kumar and Choudhary (2002), Chattopadhyay and Mukhopadyay (2003), Kumar (2005) and Mahmud *et al.* (2005).

The dry matter of curd percentage was found to differ significantly due to boron and ammonium molybdate treatments. The treatment T_9 recorded significant higher dry matter of curd (11.37 %) as compared to all the remaining treatments except T_7, T_8, T_{10} and T_{11} (9.39 to 9.36%). The second best treatment was T_{12} (10.35%). Which was significantly superior to T_1 and T_2 (7.45 to 7.61%) treatments only. Thus, the lower dry matter of curd (7.45 to 7.61%) was obtained from control treatment T_1 and T_2 to T_6 were found statistically identical to each other (7.61 to 9.29%). These results have been supported by the findings of Muthoo *et al.* (1987), they reported that the beneficial effect of molybdenum in increasing the plant growth and development. This increase in the growth and development might have been due to activated physiological process by stimulating factor in the metabolism and growth of the plant.

The A, B and C grading of curd were performed in each treatment in percentage and the values so obtained were statistically computed as indicated in Table 2. The treatment T^8 registered the maximum 'A' Grade curds (52.54%) as well as 'B' grade curds (35.20%) and the lowest 'C' grade curds (12.26%). This was equally followed by T_7 and T_9 treatments where 'A' grade curds ranged from 49.83 to 50.11%, 'B' grade curds from 35.15 to 35.25% and 'C' grade curds ranged from 14.74 to 15.65%. The lowest "A" grade curds 46.57% were found in case of control treatment T_1, this was followed by T_2 giving 46.64% 'A' grade curds, 33.09% 'B' grade curds and 20.01% C grade curds. The remaining treatments, viz. T_3 to T_6 and T_{10} to T_{12} were found in intermediate position with regard to grading of cauliflower curds.

SUMMARY

The experiment was conducted in the experimental field of Department of Horticulture, College of Agriculture, Rewa under Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during the *rabi* season 2009-2010. The results showed that morphological characters of cauliflower (*Brassica oleracea* var *botrytis* L.) increased significantly with the different levels of boron and molybdenum at every stage of observation. At 60 DAT, the maximum plant height (34.35 cm), number of leaves/plant (19.45), leaf length (32.02 cm), leaf width (28.31 cm) and stem girth (5.14 cm) were recorded in treatment T_9, whereas the minimum plant height (32.50 cm), number of leaves/plant (16.49), leaf length (29.07 cm), leaf width (25.72 cm) and stem girth (4.50 cm) were observed in control treatment T_1. Yield and quality parameters were also influenced significantly due to various treatments of boron and molybdenum. The highest curd diameter (18.41 cm), fresh- weight of curd (1.24 kg), yield/ha (400.29 q) and dry matter of curd (11.37 %) were recorded in treatment T_9, whereas the lowest curd diameter (15.52 cm), fresh weight of curd (0.69 kg), yield/ha (218.28 q) and dry matter of curd (0.69 %) were found in control treatment T_1. The treatment T_9 was found significantly superior over all the treatments. The treatment T_8 registered the maximum 'A' grade curds (52.54%) as well as 'B' grade curds (35.20%) and the lowest 'C' grade curds (12.26%). This was equally followed by T_7 and T_9 treatments. The lowest 'A' grade curds 46.57% were found in case of control treatment T_1, this was followed by T_2 giving 46.64% 'A' grade curds, 33.09% 'B' grade curds and 20.01% C grade curds.

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