Research Article

Current Horticulture 14(3): 3-15, July–September 2026

DOI: 10.5958/2455-7560.2026.00045.2

Received: 6 February 2024; Revised: 10 May 2026: Accepted: 4 September 2024

Response of cauliflower (*Brassica oleracea*) to different doses of boron and molybdenum on growth, yield and quality in Bundelkhand region

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Abstract

The response of cauliflower (*Brassica oleracea* L. var. *botrytis*) cv. Pant Shubra to different doses of boron and molybdenum on its growth, yield and was conducted at, Research Farm, RLBCAU, Jhansi (Uttar Pradesh) during 2020-21. The treatments comprised application of boron in the form borax @ 10 and 20 kg/ha and molybdenum in the form of ammonium molybdate (A.M.) @ 1 and 2 kg/ha along with RDF (100:60:80). All treatments were allotted as per randomized block design. The plant height, number of leaves, leaf length, leaf width, stem girth, plant spread and leaf area, number of days to curd initiation, number of days to curd maturity, curd diameter, fresh weight of curd, yield/plot and yield/ha. Among all the treatments, T_6 (borax @ 20 kg/ha + ammonium molybdate 2 kg/ha + RDF) was found to be significant. Cauliflower quality components such as chlorophyll content, T_8 (ammonium molybdate 2kg/ha) was found to be the best, T_5 (borax @ 20 kg/ha + ammonium molybdate 1 kg/ha + RDF) recorded the highest TSS, and T_6 (borax @ 20 kg/ha + ammonium molybdate 2 kg/ha + RDF) was significant for protein content, ascorbic acid content, and dry matter content. In grading of curds, the highest A-grade curds were observed in T_6. Among all treatments, the maximum net income and B: C ratio were observed in T_6 (borax @ 20 kg/ha + ammonium molybdate 2 kg/ha + RDF). Therefore the application of borax @ 20 kg/ha and ammonium molybdate @ 2 kg/ha along with RDF was found to be best treatment for Bundelkhand conditions of Jhansi.

Key words: Curd, TSS, Boron, Molybdenum, Yield, Quality, Protein, Ascorbic acid

Cauliflower (*Brassica oleracea* L. var. *botrytis*), a biennial crop, belongs to family Brassicaceae (Cruciferae) with diploid chromosome number 2n = 2x=18. Cauliflower requires very high amount of macronutrient and micronutrients for better development and quality curd production (Ningawale *et al.,* 2016). Boron is extremely vital to plants (Warington, 1923) and its concentration in soil and irrigation water is a key predictor of agricultural output (Tanaka and Fujiwara, 2007). Jakhar *et al.* (2018) reported that application of boron @ 2.5 kg/ha improves yield, quality and provides early crop in cauliflower. Molybdenum (Mo) is one of the important micronutrient.

The Mo application could promote the growth of Chinese cabbage, increase its yield, raise the contents of chlorophyll, and could change the leaf colour to dark green (Nie *et al.,* 2018). Mo application generally increased curd weight and diameter in cauliflower (Kotur 1995), Molybdenum deficiency in cauliflower causes a distorted growth point, which prevents the development of a head, as well as leaf blades that are primarily made up of midribs, which is known as whip tail of cauliflower (Sharma, 2002). Although boron and molybdenum sole application benefits the plants, but combined application was found to be more beneficial in terms of growth, yield and quality of cauliflower. The highest plant growth, yield/ha and dry matter content ratio was found in combined application of borax@ 10 kg/ha + ammonium molybdate@ 1 kg/ha (Ningawale *et al.,* 2016). Singh *et al.* (2017) also reported that combined application of borax @ 20 kg/ha + ammonium molybdate @ 2 kg/ha + RDF recorded the maximum plant height (60.95 cm) and width of leaf (20.24 cm). Pankaj *et al.* (2018) reported that combined application of boron 2 kg/ha + Mn 2.5 kg/ha + Zn 3 kg/ha recorded highest yield, TSS (8.80 Brix), and Vitamin-C (94.80 mg/100g). Therefore trail was conducted to find out suitable dose of boron and molybdenum for improved growth, yield and quality of cauliflower in Bundelkhand region.

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MATERIALS AND METHODS

The experiment was conducted at Research Farm of the RLBCAU, Jhansi (Uttar Pradesh), during *rabi* 2020-21 (November-January). The maximum temperature was 26.7 ^{0}C and minimum temperature 5.2 ^{0}C. The soil sample was taken before transplanting and nutrient status of soil was determined and found that it was a clay loam soil having pH 6.8, organic carbon content is 0.45%, electric conductivity is 0.29 dS/m and N, P and K content is 232.2, 15.1 and 254.1 kg/ha respectively.The experiment consisted of 10 treatments of borax and ammonium molybdate. The doses of 10 and 20 kg/ha of borax and 1 and 2 kg/ha of ammonium molybdate was taken. These doses of borax and ammonium molybdate were allotted into ten treatments as:1) T_1-10kg/ha Borax + 0kg/ha ammonium molybdate + RDF 2)T_2-10 kg /ha borax + 1kg/ha ammonium molybdate + RDF 3)T_3 -10kg /ha borax

+ 2kg/ha ammonium molybdate + RDF 4)T_4 -20kg/ha borax + 0kg/ha ammonium molybdate + RDF 5)T_5 -20kg/ha borax + 1kg/ha ammonium molybdate + RDF 6) T_6 -20kg/ha borax + 2kg/ha ammonium molybdate + RDF 7) T_7 -0kg/ha borax + 1kg ammonium molybdate+ RDF 8) T_8 -0 kg /ha borax + 2kg/ha ammonium molybdate + RDF 9) T_9 -RDF 10) T_{10} -control.

The cauliflower cv. Pant Shubra seeds were sown in nursery bed on 15th October 2020. The experimental field was ploughed 2-3 times using tractor drawn-cultivator followed by one cross harrowing with a tractor-drawn harrow. The FYM @ 200 q/ha was uniformly applied during final ploughing and then field was levelled using leveller. The healthy seedlings of 25 days old were transplanted in straight line with a distance of 60 cm (row-to-row) and 45 cm (plant-to-plant). Following the transplanting, a light irrigation was applied, with subsequent irrigation continuing every 10-12 days, weed control was carried out by 2-3 hand weeding and earthing up was done after 6 weeks of transplanting, which is very important because earthing-up provide good anchorage for developing curd.

The plant height, number of leaves, leaf length, leaf width, girth of stem, leaf spread, and leaf were recorded 30, 45 and 60 days after transplanting (DAT). The days to curd initiation from transplanting (days), days to curd maturity from initiation (days), diameter of curd (cm), fresh weight of curd (kg), yield (kg/plot) and yield (kg/ha) were recorded. The grading of curd as 'A' grade curd > 15 cm diameter, 'B' grade curd 10-15 cm diameter and 'C' grade curd < 10 cm, curd diameter (cm), dry matter content (%), TSS, ascorbic acid content (mg/100g), protein content (%), chlorophyll content (mg/100g) were recorded.

RESULTS AND DISCUSSION

The significant plant height was recorded, T_6 at 30 (44.20 cm), 45 (56.47 cm) and 60 (62.53 cm) DAT. The minimum plant height was recorded in T_{10} (control). The maximum stem girth was recorded in T_6, the stem girth recorded by T_6 (1.55cm, 3.11 cm and 5.19 cm at 30, 45 and 60 DAT respectively) and it was followed by T_5 and T_3 (Table 1). The minimum stem girth was recorded by T_{10} (control). The plant spread recorded at 30 (37.00 cm), 45 (59.07 cm) and 60 (68.52 cm) DAT revealed that application of Borax @ 20 kg/ha + A.M. @ 2kg/ha + RDF (T_6), recorded the maximum plant spread and it is closely followed by T_2, T_5 and T_3 (Table 1) whereas, lowest plant spread was recorded under T_{10} (control).

The number of leaves recorded by T_6 (Borax @ 20 kg/ha + A.M. @ 2kg/ha + RDF) was found to be significantly superior over all treatments. The minimum number of leaves recorded by the T_{10} (control) Fig. 1. The maximum leaf length of 37.20 cm, 45.25 cm and 52.58 cm at 30, 45 and 60 DAT respectively, recorded by T_6 and minimum leaf length was recorded by T_{10} (Table 1). The maximum leaf width at 30 (15.87 cm) and 60 (28.78 cm) DAT was recorded by T_6 and at 45 DAT, T_5 (21.53 cm) recorded maximum leaf width and minimum was recorded by T_{10} (Table 1). Among all the treatment, the maximum leaf area at 30 and 60 DAT 0.59 and 1.51 cm^2 respectively, was recorded by T_6 and at 45 DAT by T_5 (0.97 cm^2). The leaf area recorded by remaining treatments was identical to each other and significantly minimum leaf area was recorded by T_{10}, control.

The results in accordance with Singh *et al.* (2017) reported that height of plant, number of leaves, leaf width and leaf length increased significantly by application of boron and molybdenum on cauliflower. Treatment T_{12} (borax 20 Kg/ha + sodium molybdate 2kg/ha) has highest 60.95 cm plant height, number of leaves (21.35), leaf width (20.24 cm) and leaf length (51.85), whereas lowest was recorded in control. Kumar *et al.* (2010) reported maximum no. of leaves (21.80), leaf length (51.90cm) and leaf width (19.98 cm) under the soil application of borax @ 20kg/ha + sodium molybdate @ 2kg/ha along with 120: 60: 60 kg/ha. Ningawale *et al.* (2016) reported that highest stem girth (5.14 cm) was recorded in case of T_9 (borax @10 kg+ ammonium molybdate @1 kg/ha) followed by T_{12} (borax @20 kg+ ammonium. molybdate. @ 2kg/ha) soil application and both treatments were at par. stem girth (5.12 cm).

The significantly lowest stem girth (4.50 cm) was recorded in control (T_1). Moniruzzaman *et al.* (2007) reported that maximum plant spread (72.60 cm) of broccoli was recorded under $B_{1.5}$ (boron @ 1.5 kg/ha). Whereas, minimum plant spread (60.78 cm) was recorded under B_0 (control). Taheri *et al.* (2020) reported maximum plant height (36.33 cm), maximum plant spread (57.42 cm) were recorded T_8 (foliar application of zinc and boron @ 1%) and the lowest result for these parameters were found in To (control). Ranjan *et al.* (2019) showed that application of micronutrients (B, Mo and Zn) helped in increasing the stem diameter (3.32 cm) of cauliflower.

The days required for curd initiation and curd maturity of cauliflower responded significantly to different doses of borax and ammonium molybdate. The data regarding number of days to curd initiation in cauliflower revealed that T_6 was found to be early in curd initiation, followed by T_2, however T_6 had a significant edge over T_2 (Table 2) and late curd initiation was recorded in control (T_{10}). Similarly, the number of days required for curd maturity from initiation is significantly minimum in T_6, and it is closely followed by T_5, T_4 and T_3 (Table 2), and T_{10} was found to be the late maturing among all treatments.

The maximum curd diameter was recorded under T_6 and it is followed by T_5 (Table 2), and minimum curd diameter was recorded under T_{10} (control). The maximum fresh weight of curd was recorded under T_6, followed by T_5 and T_4 and all three treatments were on par. The minimum fresh weight was recorded under T_{10} (control). The yield recorded by T_6 was significantly superior among all the treatments followed by, T_5 and minimum yield per plot among all treatments was recorded under T_{10} (control). The maximum yield per ha was recorded by T6 and it was closely followed by T_5 and T_4. The minimum yield was recorded under T_{10} (control).

The findings were in agreement with Ningawale *et al.* (2016), and Kumar *et al.* (2010) reported maximum yield (285.82 q/ha) of cauliflower under T_{12} (borax 20 kg/ha + sodium molybdate 2kg/ ha). Similar kind of results with respect of yield of cauliflower also reported by Singh *et al.* (2017) who stated that, application of borax 20 kg/ha + sodium molybdate 2kg/ha (T_{12}) has recorded the highest yield of 254.63 q/ha and Mori *et al.* (2020) also reported that the highest yield were observed under combined application of Zn, B and Mo in cauliflower.

The cauliflower curds were graded according to their diameter as, A->15 cm, B-10 to 15 cm and C-<10 cm. The data regarding the grading of curds (Table 2) revealed that the highest percentage of A and B grade curds were recorded under T_6 and highest percentage of C grade curds were recorded under T_{10}. The data regarding the chlorophyll content, TSS, protein content, ascorbic acid content revealed that there was significant effect of borax and ammonium molybdate on cauliflower quality. The maximum chlorophyll content was recorded under T_8 and the minimum was recorded under T_{10}. The highest TSS was recorded under T_5 and it was closely followed by T_6 and the lowest TSS was recorded under T_{10}. The protein content recorded by T_6 was significantly superior over all treatments and it was nearly followed by T_5, and the significantly minimum protein content was recorded under T_{10}. Ascorbic acid content recorded by T_6 was the highest and significant among all treatment and it was followed by T_3 (Table 2), the minimum ascorbic acid content among all treatments was recorded under T_{10} (control).

Pankaj *et al.* (2018) observed higher ascorbic acid (87.68 mg/100g) under B + Mo treatment than control in sprouting broccoli and also reported that enhanced TSS content in broccoli can be achieved by combined application of (B + Mn + Zn), Thapa *et*

Table 1: Effect of borax and ammonium molybdate on morphological characters of cauliflower

Treatment	Plant height (cm)			Stem girth (cm)			Plant spread (cm)			Number of leaves			Leaf length (cm)			Leaf width (cm)			Leaf area (m^2)		
	Days after transplanting			Days after transplanting			Days after transplanting			Days after transplanting			Days after transplanting			Days after transplanting			Days after transplanting		
	30	45	60	30	45	60	30	45	60	30	45	60	30	45	60	30	45	60	30	45	60
T_1 (borax @10 kg/ha+ RDF)	37.73	41.58	53.83	1.38	2.33	4.52	45.53	52.00	64.17	13.27	16.50	17.13	33.33	38.03	44.10	13.57	18.97	21.50	30	45	60
T_2 (borax @ 10 kg/ha + A.M. 1 kg/ ha + RDF)	36.80	44.50	52.83	1.32	2.52	4.92	40.07	48.23	67.17	11.67	15.61	15.61	30.73	38.58	47.40	12.57	18.13	24.33	0.45	0.72	0.95
T_3 (borax @ 10 kg/ha + A.M. 2 kg/ ha + RDF)	36.23	44.52	57.73	1.42	2.66	4.87	45.47	52.63	65.65	12.87	16.58	16.63	30.80	41.43	44.98	13.47	19.68	21.47	0.39	0.70	1.15
T_4 (borax @ 20 kg/ha +RDF)	40.23	45.17	55.40	1.39	2.83	4.75	41.40	51.23	64.37	12.93	16.75	16.50	32.13	41.07	46.50	13.00	20.37	22.60	0.42	0.82	0.96
T_5 (borax @ 20 kg/ha + A.M. 1 kg/ ha + RDF)	39.63	53.58	58.62	1.42	2.97	5.03	46.07	55.03	67.07	13.73	17.87	17.93	32.93	43.60	50.33	14.93	23.00	27.85	0.42	0.84	1.05
T_6 (borax @ 20 kg/ha + A.M. 2 kg/ ha + RDF)	44.20	56.47	62.53	1.55	3.11	5.19	51.00	59.07	68.52	14.95	18.42	18.50	37.20	45.25	52.58	15.87	21.53	28.78	0.49	1.00	1.40
T_7 (A.M. @ 1 kg/ha + RDF)	38.90	49.67	54.43	1.32	2.37	4.93	43.00	54.27	63.77	12.40	15.50	15.58	32.67	40.03	44.65	14.90	20.90	22.70	0.59	0.97	1.51
T_8 (A.M. @ 2 kg/ha + RDF)	41.60	42.83	50.73	1.49	2.38	4.8	45.24	51.80	58.77	11.90	14.92	15.26	31.13	41.62	46.93	15.47	21.08	26.37	0.49	0.84	1.01
T_9 (RDF)	37.63	41.25	50.53	1.33	2.13	4.54	42.87	50.33	58.20	12.20	15.98	16.08	30.30	37.03	44.05	14.93	19.28	21.67	0.48	0.88	1.24
T_{10} (control)	33.23	37.53	42.62	1.33	1.92	4.27	37.00	45.47	54.47	11.80	14.37	14.65	29.80	34.60	38.29	11.50	15.65	19.72	0.45	0.71	0.95
SE(d)±	2.21	1.30	2.45	0.06	0.1	0.07	2.34	1.74	1.83	0.87	0.62	0.71	1.18	0.83	1.85	0.78	1.45	0.78	0.40	0.58	0.75
C.D. (5%)	4.52	2.66	5.02	0.12	0.21	0.15	4.79	3.55	3.74	1.79	1.27	1.46	3.69	1.69	3.78	1.60	2.96	1.59	0.04	0.06	0.04
CV (%)	7.01	3.49	5.57	4.97	4.97	1.90	6.56	4.09	3.54	8.39	4.66	7.98	6.89	2.52	4.93	6.74	8.91	4.02	0.08	0.12	0.09

Fig. 1: Effect of borax and ammonium molybdate on growth and yield of cauliflower

al. (2015) observed the maximum TSS (9.02^0 Brix) and ascorbic acid (51.52 mg/100) content of broccoli heads under application of 18 kg borax/ha and 1.5 kg ammonium molybdate/ha. Nie *et al.* (2008) reported that molybdenum application significantly increases chlorophyll content, ascorbic acid, soluble sugar, and soluble protein in Chinese cabbage.

The treatment T_6 (borax @ 20 kg/ha and ammonium molybdate @ 2 kg/ha) recorded the maximum curd yield of 258.67 q/ha and it also recorded the highest net returns of ₹ 1,51,715 and B:C ratio of 3.58, followed by (Table 2) lowest curd yield and net income was found in T_{10} (control) ie, 150.32 q/ha and ₹ 74,740.

CONCLUSION

The yield of cauliflower significantly increased due to combined application of boron and molybdenum as compared to individual application of either boron or molybdenum. The quality of cauliflower in terms of protein, vitamin-C, TSS, was found to be significantly superior with combined application of boron and molybdenum. Among all the treatments, borax @ 20 kg/ha + 2 kg/ha ammonium molybdate was to be best as it improved growth, yield and quality in Bundelkhand region (Jhansi). The application of borax @ 20 kg/ha + 2 kg/ha ammonium molybdate is most remunerative as it expressed the maximum income with a highest B:C ratio of 3.58.

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Table 2: Effect of borax and ammonium molybdate on yield and quality traits of cauliflower

Treatment	Days to curd initiation from transplanting	Days to curd maturity from initiation	Curd diameter (cm)	Fresh weight of curd (kg)	Yield per plot (kg/plot)	Yield per hectare (q/ha)	Grading of curd (%)			Chlorophyll content (mg/100g)	TSS (^{0}Brix)	Protein content (%)	Ascorbic acid (mg/100g)	Dry matter content (%)	Net income	B:C ratio
							Grade A	Grade B	Grade C							
T_1 (borax @10 kg/ha+ RDF)	47.67	17.67	14.75	0.78	12.01	189.22	46.74	33.18	18.10	71.02	9.9	16.37	56.29	17.48	102504	2.60
T_2 (borax @ 10 kg/ha+ A.M.1 kg/ha + RDF)	43.67	15.67	14.39	0.65	13.01	205.09	48.14	35.15	15.38	67.48	9	14.91	61.30	19.3	112250.5	2.70
T_3 (borax @ 10 kg/ha + A.M. 2 kg/ha + RDF)	44.00	17.33	15.58	0.74	12.24	192.90	47.58	33.63	18.34	67.29	7.03	17.19	72.03	24.19	102908	2.46
T_4 (borax @ 20 kg/ha)	45.00	15.67	15.50	0.86	13.50	212.75	48.73	34.79	17.61	65.78	8.2	16.94	60.27	17.57	118453.5	2.88
T_5 (borax @ 20 kg/ha + A.M.1 kg/ha + RDF)	44.33	15.67	18.89	0.96	14.46	228.00	49.73	35.28	15.13	66.97	10.13	17.22	66.90	15.56	130411	3.21
T_6 (borax @ 20 kg/ha + A.M. 2 kg/ha + RDF)	42.00	13.67	20.88	1.17	16.41	258.67	52.17	36.13	12.95	71.22	10	18.12	85.60	26.11	151715	3.58
T_7 (A.M. @ 1 kg/ha)	45.00	16.00	16.07	0.82	12.36	194.74	48.69	33.19	18.80	71.45	9.1	15.24	59.56	15.3	105666	2.61
T_8 (A.M. @ 2 kg/ha + RDF)	44.00	17.00	15.50	0.64	11.93	188.12	50.08	34.61	18.58	84.43	9.63	14.26	71.33	24.04	99843	2.42
T_9 (RDF)	47.33	18.33	14.53	0.50	10.36	163.19	45.54	32.84	20.68	62.18	8.43	13.39	65.98	15.41	83501.5	2.14
T_{10} (control)	48.67	19.33	11.32	0.41	9.59	150.32	44.10	32.37	21.58	61.74	6.65	10.55	46.22	13.54	74740	1.90
SE(d)±	0.70	0.39	0.88	0.09	0.35	5.51	0.81	0.38	0.42	1.02	0.1	0.35	0.70	0.81		
C.D. @ 5%	1.42	0.79	1.80	0.19	0.71	11.27	1.66	0.79	0.86	2.04	0.2	0.71	1.42	1.65		
Coefficient of variation (%)	1.89%	2.86%	6.86	14.94	3.38	3.40	2.07	1.38	2.91	3.62	1.33	2.76	1.32	5.26		

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