Effect of Boron and Zinc on growth and yield attributes in early cauliflower (*Brassica oleracea* var. *botrytis* L.)

ABSTRACT

The present experiment was carried out in cauliflower to study the effect of boron and zinc on growth and yield in the early cauliflower having combinations of four levels 0, 1, 2, 3 kg ha-1 of boron and four levels 0, 2.5, 5.0, 7.5 kg ha-1 of zinc in a factorial randomized block design with three replications during the year 2016 and 2017 respectively. The results of the experiment with applied boron and zinc had significant effect on growth and yield of cauliflower. The highest curd depth (8.88 cm) and curd equatorial diameter (16.45 cm) was found with applied boron (2 kg ha-^{1}) and zinc (2.5 kg ha-^{1}) respectively. While as, maximum net curd weight (410g) and marketable curd weight (695g) was found with sprayed boron and zinc (1 kg ha-^{1} + 2.5 kg ha-^{1}) respectively., Maximum harvest index (62.8 %) and yield (113.89 q ha-1) was found when applied with boron (2 kg ha-^{1}) and (2 kg ha-^{1}+ 2.5 kg ha-^{1}) respectively. Maximum curd compactness (34.34) and dry matter compactness (14.48) were found with the application of boron (1 kg ha-^{1}) and zinc (2 kg ha-^{1}+2.5 kg ha-^{1}) respectively. Overall findings indicated that with the increase in concentration of boron and zinc the vegetative growth and the reproductive stage of cauliflower increases respectively.

Keywords: Boron,cauliflower, yield, growth,zinc.

Introduction

Cauliflower is one of the important cool season vegetable crop grown for its flavor nutrition, delicious taste, and sensitivity to soil and climatic requirements [1].which is botanically known as *Brassica oleracea* var. *botrytis* L. having chromosome number 2n=18comes under the family crucifereae.

Among many factorsresponsible for low productivity of cauliflower, inadequate and imbalanced nutrition occupy the top position causing nutrient deficiency, particularly of boron, which are more responsible for deteriorated soil health and yield stagnation [2].Soil application of micronutrients may not be readily available to plants. The foliar sprays could be beneficial to cover up the deficiencies of these nutrients. Every micronutrient has specific role to play in the plant and its presence in optimum concentration is necessary for the plant to complete its life cycle, which ends with maturity and harvesting of the economic production. Over the years, with intensive cultivation, Indian agriculture has moved from an era of single element deficiency to more complex multiple nutrient deficiencies [3]. This is true especially in the case of micronutrients. The widespread deficiency of micronutrients has increased with the introduction of high yielding varieties of crops which remove higher amount of nutrients and the adoption of modern agricultural technology such as multiple cropping system, irrigation, intensive use of high analysis fertilizers with concomitant decrease in recycling of crop residues and use of animal manures. Full benefits of applied nitrogen, phosphorus and potassium fertilizer can only be obtained provided the availability of micronutrients is adequately ensured. Among the micronutrients, occurrence of zinc (Zn) deficiency is quite common and widespread, followed by boron (B) in the soils of Bihar.Zinc is an indispensable micronutrient for proper plant growth and development. It plays an important role in different plant metabolic processes such as enzyme activity, development of cell wall, respiration, photosynthesis, chlorophyll formation and other biochemical functions [4]. It is essential component of many enzymes such as carbonic anhydrase, alcohol dehydrogenase, superoxide dismutase and RNA polymerase etc. and also involved in nitrogen metabolism. The deficiency of Zn in plants disrupts these processes resulting in reduced plant growth, yield and quality[5].

The magnitude of Zn deficiency varies widely with the soil types, while the rate of application varies with crops, soil type and climatic conditions. Zinc deficiency occurs commonly in coarse textured, calcareous or alkaline pH, low organic carbon and highly eroded soils. Zinc deficiency in Indian soils occurred in 46 per cent soils [6]. In Zn deficient plants, middle leaves show development of golden yellow or orange colour in the interveinal portion. The young leaves remain small in size and often termed as “little leaf” or “rosetting”[7].

Boron is required for the translocation of sugars, root extension and growth of meristematic tissues, the pyrimidine biosynthetic pathway and the ATPase; it is also involved in translocation of sugars, synthesis of amino acid, protein and carbohydrate metabolism. Further, it plays a vital role in pollen enlargement, fertilization and flowering processes of plants. Boron deficiency affects development of terminal bud of shoots and growing root tips in plants, since it is immobile in plants. Therefore its deficiency, adversely affects the yield and quality of the seeds and fruits. The effects on the yield can occur despite no deficiency symptoms are evident on the foliage. This physiological phenomenon is referred to as 'hidden hunger' which is the reason for B deficiency being an unsuspected enemy of crop production for a long time.

Boron deficiency is most widespread next to Zn causing heavy yield reduction in horticultural crops [8]. Incidence of B deficiency is very high in the States of West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh and Tamil Nadu. The B deficiency is critical for crop productivity in highly calcareous, sandy, leached, lime applied acidic and laterite soils. According to All India Coordinated Research Project on Micronutrients (ICAR), B deficiency in Indian soils ranged from 0 to 68 per cent with a mean of 33 per cent [9].

Boron deficiency occurs in wide array of cruciferous crops such as cauliflower (brown heart), beetroot (heart rot), turnip (brown heart), and also groundnut (hollow heart). Cole crops including cauliflower require higher quantities of B for proper growth and development [10]. In cauliflower, boron deficiency first appears as water-soaked patches on the developing head of cauliflower which soon turn brown and may rot. The leaves curl down and become brittle. Blistering may occur on the petiole and along the midrib. The pith stem below the curd breaks down and develops the cracks which later on form an elongated cavity.The deficiency of boron in cauliflower causes browning of curds and the development of hollow stems which directly affects the marketing of cauliflower [11].

Moreover, limited research work has been reported on the effects of zinc and boron in early cauliflower production in the Nalanda district of Bihar. The present research, therefore, was conducted to determine the effects of different doses of zinc and boron on the growth and yield attributes of early cauliflower in the Nalandadistrict Bihar.. However, correcting micronutrient deficiencies through foliar application is an effective method due to easy absorption through leaves results in getting profitable yield [12].

Material & Methods

A field experiment was conducted to test the impact of zinc and boron on cauliflower production, yield and quality (*Brassica oleraceae* var. botrytis L.) in 2016 and 2017 at NalandaCollege ofHorticulture Noorsarai, *i*.e. in the southern part of Bihar. The study site's soil was coarse sandy loam with an estimated 903.5 mm annual rainfall having 4°C-44°C temperature spectrum and 30 to 95% relative humidity. The experiment was performed with three replications in a factorial randomized block design as per treatment details in Table 1. Seedlings were transplanted at the spacing of 50 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. For three replications, the trial consisted of sixteen treatments; each distributed arbitrarily according to the random number table process.

Table1.Description of the treatments

S.No.	Treatment	Details	S.No.	Treatment	Details
1.	T_1 - B_0 Zn_0	0 kg ha^{-1}+ 0 kg ha^{-1}	9.	T_9 - B_2 Zn_0	2.0 kg ha^{-1}+ 0 kg ha^{-1}
2.	T_2 - B_0 $Zn_{2.5}$	0 kg ha^{-1}+ 2.5 kg ha^{-1}	10.	T_{10} - B_2 $Zn_{2.5}$	2.0 kg ha^{-1}+ 2.5 kg ha^{-1}
3.	T_3- B_0 $Zn_{5.0}$	0 kg ha^{-1}+ 5.0 kg ha^{-1}	11.	T_{11} - B_2 $Zn_{5.0}$	2.0 kg ha^{-1}+ 5.0 kg ha^{-1}
4.	T_4 - B_0 $Zn_{7.5}$	0 kg ha^{-1}+ 7.5 kg ha^{-1}	12.	T_{12} - B_2 $Zn_{7.5}$	2.0 kg ha^{-1}+ 7.5 kg ha^{-1}
5.	T_5 –B_1 Zn_0	1.0 kg ha^{-1}+ 0 kg ha^{-1}	13.	T_{13} - B_3 Zn_0	3.0 kg ha^{-1}+ 0 kg ha^{-1}
6.	T_6 - B_1 $Zn_{2.5}$	1.0 kg ha^{-1}+ 2.5 kg ha^{-1}	14.	T_{14} - B_3 $Zn_{2.5}$	3.0 kg ha^{-1}+ 2.5 kg ha^{-1}
7.	T_7 - B_1 $Zn_{5.0}$	1.0 kg ha^{-1}+ 5.0 kg ha^{-1}	15.	T_{15} - B_3 $Zn_{5.0}$	3.0 kg ha^{-1}+ 5.0 kg ha^{-1}
8.	T_8 - B_1 $Zn_{7.5}$	1.0 kg ha^{-1}+ 7.5 kg ha^{-1}	16.	T_{16} - B_3 $Zn_{7.5}$	3.0 kg ha^{-1}+ 7.5 kg ha^{-1}

Soil Sampling and Laboratory Analysis

Samples of composite soil were taken before the cauliflower seedlings were transplanted from each block. The samples were air-dried and processed using mm^{2}sieve. Testing was performed for nitrogen, phosphorus, potassium, boron, and zinc. Table 2 described the chemical properties of the experimental soil.

Table 2: Chemical properties of the soil

Soil parameter	**Values**	**Status**
Soil pH (1 : 2.5)	7.6	Medium
EC (dS/m)	0.10	Medium
Organic carbon (%)	0.61	Medium
Available N (kg/ha)	181.88	Low
Available P_2O_5 (kg/ha)	34.93	Medium
Available K (kg/ha)	138	Medium
Available S (ppm)	18.2	Medium
Boron (ppm)	0.60	Medium
Zinc (ppm)	1.85	Medium

. The data were taken from randomly selected five plants on various characteristics from each plotsize 8.10m^2, plant height, stem length, number of leaves per plant, leaf area, days to 50 percent curd formation, curd depth (polar diameter)(cm), curd compactness, gross curd weight (kg / field), net curd weight (g / plant), marketable curd weight (g), marketable curd yield (q / ha) and dry mattercontent of curd (%) and harvest index (%).

Results

Growth parameters

Significant variation was observed for all the growth parameters except for stem length and days to 50% curd initiation. The plant height was significantly influenced at different levels of boron and zinc application(Table 3).The significantly superior plant height was observed in treatment T_7(68.25) which was statistically similar to T_6 (65.98) and T_8 (64.76).There was remarkable variation found in leaves per plant at harvest. The number of leaves per plant were highest in treatment T_8, T_9 and T_{11}(22) which was significantly at par with all other treatment whereas control treatment represented the minimum number of leaves per plant (16).It is evident from the table that leaf area showed considerable amount of variation. The maximum leaf area was observed in treatment T_{10} (697.11) followed by T_3 (696.99) and T_{12} (657.13).This might be due to enhancement of cell multiplication and cell elongation due to boron.These results are in agreement with those of [13]and [14]

Yield components

A significant effect of micronutrient application was observed on yield components. The curd depth responded significantly to different micronutrients treatments (Table 1) and it increases as micronutrient was applied at varying rates. Maximum curd depth was recorded in treatment T_{10}(8.88) and was statistically at par with treatment T_{12}(8.57)and T_6 (8.49).Among different sources of micronutrient, treatment T_{10}proved its superiority over others as the maximum curd equatorial diameter (16.45).The curd diameter was statistically at parwith treatment T_9 (16.36) and T_{11} (16.12). Net curd weight, varied significantly due to the application of different doses of boron and zinc treatments. Maximum net curd weight was observed highest in treatment T_{10}(410) followed by treatment T_9(405) and T_{11}(390).A significant effect of micronutrient treatments on marketable curd weight was observed. It varied from 570g to 695g.Maximum marketable curd weight was observed highest in treatment T_6 (695). Marketable curd weight was statistically at par with the treatments T_5, $T_{10}$and T_{15}.Lowest marketable curd weight was observed in treatments $T_{1.}$

Total dry matter and curd yield

Significant amount of variation was observed for total dry matter and curd yield due to different doses of boron and zinc. Harvest index was observed maximum in treatment T_9 (62.8) which was statistically at par with the treatments T_{13} and T_{10}. Calculated yield was observed maximum in treatment T_{10}(113.89) and minimum in treatment T_1 (83.33). Curd compactness varied from 29.36 to 34.34. Treatment T_5 (34.34) observed maximum curd compactness which was significantly at par with treatment T_9 (32.77) and T_{14} (32.68). Dry Matter content in cauliflower varied significantly. It varied from 12.07 to 14.48 and was observed highest in treatment T_{10} (14.48) whereas rest of the treatment was significantly at par.

Discussions

It was found that zinc and boron combinations play an active role in cauliflower vegetative growth. The beneficial impact of micronutrients on growth parameters is due to their involvement in physiological processes and cellular functions inside plants, they also played an important role in enhancing plant growth via the biosynthesis of endogenous hormones responsible for promoting plant development.The combined application of boron and zinc affects the growth parameters *viz.*, the number of leaves per plant, leaf area and plant heightincreased significantly. Applying foliar plant nutrients, especially boron and zinc, which play a major role in vigorous vegetative growth, may have beneficial effects by imparting deep green color to the leaf. These nutrients play an essential role in the formation of chlorophyll which has influenced cell division, meristematic tissue activity, cell expansion, and cell wall formation [15]. It has stimulating and catalytic effects on metabolic processes which ultimately affect cauliflower's growth traits. These results are in line with the [16]investigation that micronutrients play vital roles in plant growth and production, which ultimately enhance flower yield and quality [17].

Result indicates that foliar application of various levels of zinc and boron varies considerably. Owing to the application of micronutrient the curd diameter and curd weight increase significantly. It stimulated chlorophyll synthesis, increased physiological activities such as those that photosynthesize from leaves to curd for translocation of plant assimilates, and their deposition in curd. Improvement in photosynthesis and other metabolic activity resulted in an increase in the various plant metabolites responsible for cell division and elongation. The higher curd yield may be due to the synergetic effect between boron and zinc applied to the plant. This can act as energy source for auxin synthesis [18] have documented an improved photosynthetic reaction in the presence of zinc and boron.

Absolute dry matter and curd compactness of rise coupled with zinc and boron production at various stages. The primitive influence of B and Zn on the transfer of further carbohydrates, proteins along with their function in improving their translocation from the synthesis site to the storage organs.it helps to improve development by using adequate nitrogen and phosphorus amounts. The results above were in consonance with [19].

Conclusion

There was significantly higher gross plant weight (kg), curd diameter (cm), curd depth (cm), net curd weight (kg) among different rates of B and Zn use. Treatment T_{10} — $B_2Zn_{2.5}$ — (2.0 kg / ha + 2.5 kg / ha) found a maximum yield of 113.89 q / ha for T_{11} — B_2 Zn_5- (2.0 kg / ha + 5.0 kg / ha) of 108.33 q / ha for calculated yield (q / ha). It can be concluded from the "Impact of application of boron and zinc supplements on growth, yielding characteristics and cauliflower quality" investigation.

Table 3.Mean of growth and yield component of cauliflower

Characters/ Treatment	Growth parameters					Yield components				Total dry matter and curd yield			
	Plant height (cm)	**Stem length (cm)**	**No. of leaves per plant**	**Leaf Size (L x B)cm^2**	**Days to 50% curd initiation**	**Curd depth (cm)**	**Curd equatorial diameter (cm)**	**Net curd weight (g)**	**Marketable curd weight (g)**	**Harvest Index %**	**Yield (q/Ha)**	**Curd Compactness**	**Dry Matter (%)**
T_1 - B_0 Zn_0	48.53	16.14	16	568.44	109	7.22	12.44	300	570	51.28	83.33	30.52	13.87
T_2 - B_0 $Zn_{2.5}$	54.59	17.27	19	605.77	105	7.8	13.08	320	595	53.78	88.87	30.65	12.07
T_3- B_0 $Zn_{5.0}$	53.98	16.22	21	696.99	102	7.12	13.2	305	580	52.59	84.72	30.02	13.23
T_4 - B_0 $Zn_{7.5}$	51.61	15.47	21	557.28	106	7.57	13	310	585	54.38	86.11	30.16	12.3
T_5 – B_1 Zn_0	51.41	17.23	20	592.99	105	8.11	13.15	365	680	53.68	101.39	34.34	12.92
T_6 - B_1 $Zn_{2.5}$	65.98	16.44	21	615.45	108	8.49	14.15	368	695	52.95	102.22	32.51	13.56
T_7 - B_1 $Zn_{5.0}$	68.25	16.47	21	510.03	108	8.43	15.07	358	655	54.66	99.44	29.36	13.48
T_8 - B_1 $Zn_{7.5}$	64.76	16.61	22	514.13	104	8.19	15	345	660	52.27	95.83	29.74	13.3
T_9 - B2 Zn0	57.64	17.37	22	607.78	103	8.22	16.36	405	645	62.8	112.5	32.77	14.3
T_9 - B_2 Zn_0	54.25	17.61	21	697.11	100	8.88	16.45	410	675	60.74	113.89	32.39	14.48
T_{10} - B_2 $Zn_{2.5}$	57	17.24	22	585.45	101	8.42	16.12	390	660	59.1	108.33	31.79	13.98
T_{11} - B_2 $Zn_{5.0}$	56.08	15.21	17	657.13	98	8.57	16	385	655	58.78	106.94	31.35	12.13
T_{12} - B_2 $Zn_{7.5}$	50.7	15.9	20	580.89	103	7.2	16.22	380	620	61.29	105.55	32.45	11.83
T_{13} - B_3 Zn_0	57.35	16.14	18	630.46	105	7.76	15.8	385	660	58.33	106.94	32.68	12.29
T_{14} - B_3 $Zn_{2.5}$	47.46	16.38	17	620.32	99	7.34	15	360	665	54.14	100	32.23	12.98
T_{15} - B_3 $Zn_{5.0}$	43.35	16.15	17	590.38	101	7.21	15.33	355	650	54.62	98.61	31.5	12.45
CD @ 5 %	6.557	NA	1.979	55.227	NA	0.719	1.162	25.758	40.198	3.953	7.659	2.116	1.392
CV	7.091	5.929	6	5.446	5.557	5.428	4.69	4.284	3.745	4.216	4,586	4.006	6.354

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