Effect of zinc and boron on yield, quality and nutritional value of Broccoli head (*Brassica oleracea* var. *italica*) with different application methods in red and lateritic soils of Birbhum district, India

ABSTRACT

The aim of the study was to *improve yield, quality and nutritional value of broccoli head with different dose and application methods of zinc and boron and also decide the best possible treatment combination. The experiment was conducted in Palli sikhsha bhavana, agriculture farm, Visva Bharati (Sriniketan) during rabi seasons of 2018-19 and 2019-20 from October to January. It was laid out in a Factorial Randomized Block Design consisting of 9 treatments of zinc and boron combination with different doses and application method replicated thrice. Three treatments of Zinc viz. Z_0 (no zinc), Z_f (foliar application @0.5% $ZnSO_4$), Z_s (soil application @25kg/ha $ZnSO_4$) and three treatments of Boron viz. B_0 (no boron), B_f (foliar application @0.5% borax), B_s (soil application @2kg/ha borax) randomized among themselves The crop was planted (spacing of 50cm X 40cm), fertilized (N: P_2O_5: K_2O::150:100:100) and irrigated as per recommended practices. Five plants from each plot were randomly selected and tagged for data collection. Treatment (T8) combined application of boron soil @2kg/ha and zinc as foliar @0.5% was found superior for total yield (28.9 ton/ha) and head weight per plot (695.4gms). Vitamin C and total chlorophyll of broccoli head significantly improved with combined application of zinc in soil @25kg/ha and boron as foliar @0.5% with highest value of 1117.5mg/g and 0.77mg/g respectively. Highest Total sugar and reducing content was recorded for combined application of boron in soil @2kg/ha as well as foliar @0.5% with value of 1.7 and 1.62. Crude protein content in broccoli head was significantly improved with zinc foliar application @0.5% with a value of 14.34%. Zinc concentration and zinc uptake by broccoli head was significantly increased by zinc foliar application @0.5% recording highest value of 0.041% and 6.67kg/ha whereas boron concentration and uptake was improved by combined application of boron soil @2kg/ha and zinc as foliar @0.5% with a value of 0.0049% and 2.26kg/ha respectively. The combined application of boron in soil @2kg/ha and zinc as foliar @0.5% would be the best treatment to impact on yield, quality and nutritional values of broccoli head in red and lateritic soils of Birbhum district.*

Keywords: **B**roccoli, zinc, boron, yield, quality

Introduction:

Red and lateritic soils cover almost 28% of geographical area of West Bengal (Anon, 1989) which are acidic in soil reaction light textured, low organic matter and P and are often deficient in S and micronutrients like Zn, B, Mo (Panda *et al.* 1991, Sakal and Singh1997). Micronutrient has specific role to play in the plant and its presence in optimum concentration is a must for the plant to complete its life cycle which ends with maturity and harvesting of the economic produce. 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 whereas 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. It plays a vital role in pollen enlargement, fertilization and flowering processes of plants.

Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas *et al.*, 2008). It is native to Mediterranean region (Decoteau, 2000) which is high in vitamin C and good source of vitamin A, B_1, vitamin B_2 and calcium. Also, it has been declared as an anti-cancer source by American Cancer Society because it contains mostly sulforaphane (from the glucosinolates group) that checks the growth of tumors and reduces the risk of cancer (Yoldas *et al.*, 2008). Zinc may represent a co-factor of the myrosinase in broccoli and favours the formation of sulforaphane at the initial reaction (Liang *et al.* 2006). Thus, the key role played by Zn and B nutrition in plant growth, the present study has been designed to find the suitable dose and method of Zn and B application for broccoli production and to improve its quality and nutritional value.

Materials and Method

The study was carried out in a n experimental site of Palli sikhsha bhavana farm, Visva Bharati (Sriniketan) in two rabi season of 2018-19 and 2019-20. The experiment consisted of 9 treatments of zinc and boron combination with different doses and application method and was laid out in factorial randomized block design replicated thrice. The treatments were as follows T1: only recommended dose of fertilizer (control); T2: RDF+ zinc foliar @0.5%; T3: RDF+ zinc soil application @ 25kg/ha; T4: RDF+ boron foliar application @ 0.5%; T5: RDF + combined application of boron foliar @0.5% and zinc foliar @0.5%; T6: RDF + combined application of boron foliar @0.5% and zinc soil @25kg/ha; T7: RDF + boron soil application @2kg/ha; T8: RDF + combined application boron soil application @2kg/ha and zinc foliar @0.5%; T9: RDF + combined application for boron soil @2kg/ha + zinc soil @25kg/ha.

Broccoli was planted (spacing of 50cm x 40cm), fertilized with (N: P_2O_5: K_2O; at a ratio 150:100:100) and irrigated as per recommended practices. The fertilizer sources for nitrogen, phosphorous and potassium were urea, DAP and muriate of potash while sources for zinc and boron were zinc sulphate heptahydrate and borax. Before fertilizer application random soil samples were collected from experimental site for analysis which revealed the initial soil status of that site (Table1).

Table 1: Initial soil status of experimental site (0-15cm)

Particulars	**Values obtained**	**Rating**	**Method**
pH	6.1	Moderately acidic	Using glass electrode pH meter with 1:2.5 soil: water suspension (Jackson, 1973
Electrical conductivity (dS/m) at 25° C	0.9	Normal	Conductivity meter (Jackson, 1973)
Organic carbon (%)	0.29	Low	Wet digestion method (Walkley and Black, 1934)
Available Nitrogen (kg/ha)	171.42	Low	Kjeldahl distillation process by using alkaline permanganate solution (Subbaiah and Asija, 1956)
Available Phosphorous (kg/ha)	16.4	Medium	Bray's No. 1 method (Bray and Kurtz, 1945).
Available Potassium (kg/ha)	183.31	Medium	Extraction with neutral normal Ammonium acetate (CH3COONH4), (Jackson, 1973)
Available Zn (mg/kg)	0.52	Low	Atomic absorption spectrophotometer using DTPA extractant (Lindsay and Norvell, 1978)
Available B (mg/kg)	0.09	Low	Hot water extractable method (Berger &Troug)

Data was collected from different growth parameters including plant height and plant spread area (canopy distribution in E-W and N-S direction) of which samples were collected at 30DAT and 60DAT. Yield data and its attributes like head weight per plot, head length and width per plant, stem girth were collected after harvesting. Quality parameters like vitamin C (dye titration method), reducing sugar (Lane and Eynon method of reducing Fehling's Solution), total sugar (Lane and Eynon method of reducing Fehling's Solution), crude protein (calculated from total nitrogen uptake) and total chlorophyll (DMSO method) were estimated as per standard procedure. Nutrient (zinc and boron) uptake was estimated after wet digestion in diacid mixture of nitric acid (HNO3) and perchloric acid at a ratio of 4:1 as per Jackson (1973) and dry ashing method respectively. Soil was again collected from each plot after harvesting for analyzing available zinc and boron and was estimated in AAS and hot water extractable method respectively.

Data was analyzed using analysis of variance (ANOVA). Treatment means were compared using standard error of the mean difference (Sd) and least significant difference (LSD) at $\alpha = 0.05$ level of significance in Microsoft excel (Gomez and Gomez, 1984).

Result and discussion

Growth parameters

Results in Table 2 indicated significant differences among means for values of 2018,2019 and pooled analysis such that plant height was affected by combined application of zinc and boron in both season at both growth stages. Highest value for plant height **(39.5cm)** was recorded for treatment (T2) zinc foliar application @ 0.5% at 30 DAT and combined foliar application (T5) of zinc @ 0.5% and boron @ 0.5% at 60DAT **(73.3cm)**.

The findings are similar to those reported by **Prasad *et al.* (2020)** and **Parmar *et. al* (2023)** in their experiment on effect of micronutrient in broccoli where plant growth was influenced by combined application of zinc and boron. **Quratul *et al.* (2016)** found similar response in his experiment where 0.5% application of zinc sulphate and borax increased plant height. **Chowdhury *et al* (2017)** in the research of effect of boron, zinc and molybdenum on broccoli (cv-green magic) with sole doses of these three micronutrients found 0.5% application of zinc sulphate in promoting growth of broccoli plant had similar results. Significant differences on plant spread area in (T9) combined application of zinc @25kg/ha and boron @2kg/ha was observed with highest value ($0.18m^2$). at 30DAT which was at par with results of **Singh *et al.* (2017)** whereas for 60DAT highest value ($0.33m^2$) was recorded for combined foliar application of zinc @0.5% and boron @0.5% (T5). This might be due to stimulating influence of boron enhancing rate of absorption of nitrogen, phosphorous and potassium and retained maximum vegetative growth with higher canopy area and photosynthetic rate. The results were similar with experiment conducted by **Kant *et al*. (2013)** where combined soil application of zinc and boron improved plant height and plant spread area.

Table 2: Growth parameters as influenced by Zinc and boron with different application methods at 30DAT and 60 DAT

Treatments		PLANT HEIGHT (cm)						PLANT SPERAD AREA (m2)					
		30 DAT			60 DAT			30 DAT			60 DAT		
		2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
T1		37.34	38.94	38.14	60.07	68.97	64.52	0.12	0.11	0.12	0.23	0.23	0.23
T2		39.26	39.74	**39.5**	71.15	71.5	71.33	0.15	0.15	0.15	0.32	0.32	0.32
T3		38.46	38.29	38.38	69.85	70.06	69.96	0.14	0.14	0.14	0.32	0.32	0.32
T4		38.92	36.73	37.83	69.7	69.73	69.72	0.15	0.15	0.15	0.31	0.31	0.31
T5		38.67	39.11	38.89	73.43	73.16	**73.3**	0.17	0.18	0.18	0.34	0.34	0.34
T6		38.53	37.07	37.8	69.62	69.93	69.78	0.17	0.17	0.17	0.3	0.3	0.3
T7		38.77	38.85	38.81	72.36	72.58	72.47	0.16	0.17	0.16	0.29	0.3	0.29
T8		38.67	38.12	38.39	68.61	60.33	64.47	0.15	0.14	0.14	0.29	0.29	0.29
T9		38.71	38.85	38.78	68.81	69.06	68.93	0.18	0.18	**0.18**	0.33	0.33	**0.33**
Mean		38.59	38.41	38.5	69.29	69.48	69.38	0.15	0.15	0.15	0.3	0.3	0.3
SEM	B	0.842	0.604	0.622	1.179	1.064	0.928	0.007	0.01	0	0.01	0.01	0.01
	Zn	0.842	0.604	0.622	1.179	1.064	0.928	0.007	0.01	0	0.01	0.01	0.01
	B X Zn	1.458	1.047	1.077	2.042	1.843	1.607	0.012	0.01	0.01	0.017	0.02	0.02
CD (0.05)	B	*	*	*	*	*	*	*	0.02	0.01	*	0.04	0.03
	Zn	*	*	*	*	*	*	*	0.02	0.01	*	0.04	0.03
	B X Zn	*	*	*	*	5.52	4.82	*	0.04	0.02	*	0.07	0.05
CV (%)		6.54	4.72	4.84	5.1	4.59	4.01	13.94	13.45	6.25	9.76	13	9.03

Treatments: T1: only recommended dose of fertilizer (control); T2:RDF+ zinc foliar @0.5%; T3: RDF+ zinc soil application @ 25kg/ha; T4: RDF+ boron foliar application @ 0.5%; T5: RDF + combined application of boron foliar @0.5% and zinc foliar @0.5%; T6: RDF + combined application of boron foliar @0.5% and zinc soil @25kg/ha; T7: RDF + boron soil application @2kg/ha; T8: RDF + combined application boron soil application @2kg/ha and zinc foliar @0.5%; T9: RDF + combined application for boron soil @2kg/ha + zinc soil @25kg/ha.Recommended dose of fertilizer: N: P_2O_5: K_2O::150:100:100 (kg/ha) were applied through urea, DAP and muriate of potash.

Yield and its attributes:

Results on yield and its attributed in (Table 3) showed significant differences on combined application of boron in soil @2kg/ha and zinc as foliar @0.5% (T8) for both seasons on yield and head weight per plot. Highest value **(28.9 ton/ha)** was recorded for T8 and the findings are similar to **Singh *et al.* (2017) and Sidhu *et. al* (2022)** concluded that the application of boron @2kg/ha along with zinc promoted head weight, head diameter and plant weight. **Mahmoud *et al.* (2019)** reported that combined foliar application of zinc and boron recorded highest yield. The increase in yield could be attributed to combined effect of zinc and boron at the same time for particular treatments which boosted the plant metabolism and translocated sugar and carbohydrates from site of synthesis to storage tissue in broccoli. However, there was no significant differences on head length, width and stem girth with combined application of zinc and boron. Lowest value was recorded for control plots.

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Table 3: Yield and its attributes as influenced by zinc and boron with different application methods

Treatments		Yield (ton/ha)			Head weight (gm) per plot			Head length (cm) per plant			Head width (cm) per plant			Stem girth (mm) per plant		
		2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
T1		14.41	5.93	10.17	364.61	131.96	248.28	14.19	7.82	11	12.89	8.04	10.46	38.85	28.38	33.61
T2		21.03	11.56	16.3	484.6	260.2	372.4	14.99	11.17	13.08	13.69	11.65	12.67	40.27	36.39	38.33
T3		19.51	11.12	15.32	495.94	286.18	391.06	14.76	11.37	13.06	12.59	12.17	12.38	38.73	38.01	38.37
T4		19.36	12.4	15.88	470.97	293.7	382.33	14.87	12.6	**13.74**	13.45	12.66	13.05	38.54	35.81	37.17
T5		18.37	14.34	16.36	440.04	339.61	389.83	14.33	12.29	13.31	13.73	13.17	**13.45**	41.89	37.3	39.59
T6		19.01	13.42	16.21	462.83	335.55	399.19	15.27	11.57	13.42	13.05	12.75	12.9	40.3	41.04	**40.67**
T7		15.95	6.37	11.16	467	175.22	321.11	15.08	9.75	12.42	13.18	10.11	11.64	39.42	37.83	38.62
T8		16.22	41.58	**28.9**	381.13	1009.61	**695.37**	15.68	10.94	13.31	13.12	11.5	12.31	38.18	36.48	37.33
T9		17.39	11.75	14.57	382.59	314.52	348.55	14.21	9.12	11.66	13.35	9.26	11.31	38.95	35.65	37.3
Mean		17.92	14.28	16.1	438.86	349.61	394.24	14.82	10.74	12.78	13.23	11.25	12.24	39.46	36.32	37.89
SEM	B	0.674	1.001	0.7	18.462	3.293	10.2	0.369	0.311	0.22	0.319	0.222	0.21	0.619	1.13	0.72
	Zn	0.674	1.001	0.7	18.462	3.293	10.2	0.369	0.311	0.22	0.319	0.222	0.21	0.619	1.13	0.72
	B X Zn	1.167	1.734	1.21	31.978	5.704	17.66	0.638	0.538	0.37	0.552	0.384	0.36	1.073	1.956	1.25
CD (0.05)	B	*	3.001	2.09	*	9.872	30.56	*	*	0.65	*	*	0.62	*	*	*
	Zn	*	3.001	2.09	*	9.872	30.56	*	*	0.65	*	*	0.62	*	*	*
	B X Zn	*	5.197	3.63	*	17.098	52.94	*	*	1.12	*	*	1.07	*	*	*
CV (%)		11.28	21.03	13.02	12.62	2.83	7.76	7.46	8.69	5.06	7.23	5.91	5.03	4.71	9.33	5.71

Treatments: T1: only recommended dose of fertilizer (control); T2:RDF+ zinc foliar @0.5%; T3: RDF+ zinc soil application @ 25kg/ha; T4: RDF+ boron foliar application @ 0.5%; T5: RDF + combined application of boron foliar @0.5% and zinc foliar @0.5%; T6: RDF + combined application of boron foliar @0.5% and zinc soil @25kg/ha; T7: RDF + boron soil application @2kg/ha; T8: RDF + combined application boron soil application @2kg/ha and zinc foliar @0.5%; T9: RDF + combined application for boron soil @2kg/ha + zinc soil @25kg/ha.Recommended dose of fertilizer: N: P_2O_5: K_2O::150:100:100 (kg/ha) were applied through urea, DAP and muriate of potash.

Quality aspects and nutritional value

Results in Table 4 showed significant differences in vitamin C, reducing sugar, total sugar, crude protein and total chlorophyll content in broccoli head of both seasons. It reveals Vitamin C **(1117.5mg/g)** and total chlorophyll content (0.77mg/g) in T6 was highest with combined application of zinc soil application @ 25kg/ha and boron foliar application @0.5%. The result is at par with findings by **Singh *et al.* (2017) and Al-Zubaidi *et al.* (2022)**. **Puspanjali *et al.* (2018)** recorded similar results where maximum vitamin C was in combined soil application of boron and zinc over the control plots (no micronutrients). This could be due to zinc which plays vital role in enzymatic activity and has direct role in chlorophyll content. Highest reducing sugar (1.7) in T7 in broccoli head was registered in boron soil application @ 2kg/ha and boron foliar application @ 0.5%. Total sugar content (1.62) in T4 was recorded in RDF+ boron foliar application @ 0.5%. This could be explained with the fact that boron influences the availability and uptake of other plant nutrients from the soil. An apparent increase in the uptake and translocation of P, N, K, Zn, Fe, and Cu in leaves, buds, and seeds (**Shireen *et. al*, 2018**). Highest crude protein content (14.34) was recorded in Zinc foliar application @ 0.5% since Zinc is required as structural and catalytic components of protein and enzymes for normal growth and development as reported by **Broadley *et al.*, (2007**). Highest crude protein was recorded for solo application of zinc foliar @ 0.5% (T2). Similar findings were reported by **Chowdhury *et al* (2017)** where sole application of zinc sulphate @ 0.5% have improved quality aspects of broccoli (cv 'Green magic'). **Al-Zubaidi *et al.* (2022)** reported combined application of boron and zinc improves quality aspects of broccoli. Since zinc is involved in the translocation of sugar and protein. Sole application of zinc can also be suggested. All the parameters responded significantly to treatments over control plots which recorded least value.

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Table 4: Quality attributes as influenced by Zinc and boron with different application methods

Treatments		Vitamin C (mg/g)			Reducing sugar			Total sugar			Crude protein (%)			Tot Chl in head (mg/g)		
		2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
T1		510	790	650	1.26	0.99	1.13	0.75	1.09	0.92	9.25	9.28	9.26	0.37	0.36	0.36
T2		730	1100	915	1.37	1.09	1.23	1.14	1.21	1.17	14.44	14.23	**14.34**	0.4	0.4	0.4
T3		520	915	717.5	1.39	1.07	1.23	1.32	1.35	1.34	10.85	10.97	10.91	0.48	0.58	0.53
T4		550	825	687.5	1.51	1.25	1.38	1.93	1.31	**1.62**	10.3	10.38	10.34	0.55	0.54	0.55
T5		650	975	812.5	1.4	1.07	1.24	1.1	1.11	1.1	11.2	11.38	11.29	0.63	0.62	0.62
T6		1020	1215	**1117.5**	1.43	1.13	1.28	1.37	1.31	1.34	13.68	13.59	13.64	0.79	0.76	**0.77**
T7		810	1135	972.5	1.92	1.49	**1.7**	1.1	1.15	1.12	10.79	10.5	10.65	0.57	0.56	0.57
T8		890	1110	1000	1.53	1.16	1.35	1.3	1.42	1.36	10.41	10.62	10.51	0.44	0.48	0.46
T9		600	1195	897.5	1.42	1.18	1.3	1.21	1.64	1.43	11.49	11.67	11.58	0.53	0.54	0.53
Mean		697.78	1028.89	863.33	1.47	1.16	1.31	1.24	1.29	1.27	11.38	11.4	11.39	0.53	0.54	0.53
SEM	**B**	33.64	26.83	13.55	0.07	0.05	0.04	0.08	0.07	0.05	0.08	0.11	0.08	0.02	0.01	0.01
	Zn	33.64	26.83	13.55	0.07	0.05	0.04	0.08	0.07	0.05	0.08	0.11	0.08	0.02	0.01	0.01
	B X Zn	58.27	46.48	23.46	0.13	0.09	0.06	0.14	0.12	0.08	0.14	0.19	0.14	0.04	0.02	0.02
CD (0.05)	**B**	100.85	80.44	40.61	0.22	0.16	0.11	0.25	*	0.14	0.24	0.33	0.24	0.07	0.03	0.04
	Zn	100.85	80.44	40.61	*	*	0.11	*	0.2	0.14	0.24	0.33	0.24	*	0.03	0.04
	B X Zn	174.67	139.32	70.34	*	*	0.19	0.43	*	0.25	0.42	0.57	0.42	0.12	0.05	0.06
CV (%)		14.46	7.82	4.71	15.19	13.72	8.23	19.96	15.87	11.44	2.13	2.91	2.11	13.4	5.54	6.78

Treatments: T1: only recommended dose of fertilizer (control); T2:RDF+ zinc foliar @0.5%; T3: RDF+ zinc soil application @ 25kg/ha; T4: RDF+ boron foliar application @ 0.5%; T5: RDF + combined application of boron foliar @0.5% and zinc foliar @0.5%; T6: RDF + combined application of boron foliar @0.5% and zinc soil @25kg/ha; T7: RDF + boron soil application @2kg/ha; T8: RDF + combined application boron soil application @2kg/ha and zinc foliar @0.5%; T9: RDF + combined application for boron soil @2kg/ha + zinc soil @25kg/ha.Recommended dose of fertilizer: N: P_2O_5: K_2O::150:100:100 (kg/ha) were applied through urea, DAP and muriate of potash.

Table 5 showed significant differences in the nutritional value of zinc and boron in broccoli head and plant of 2018-19, 2019-20 and pooled analysis. Results indicated highest zinc concentration and zinc uptake by plant was registered in the combined application of boron soil application @2kg/ha and zinc foliar @0.5% (T8). This could be due to roles of Zinc which boosts plant metabolism when directly applied through leaves. Highest zinc concentration and uptake was observed in zinc foliar application @0.5% (T2) (0.041 and 6.67) pooled analysis for the two seasons respectively. Boron concentration and uptake by plant was found highest in combined application of boron soil 2kg/ha and zinc foliar 0.5% (T8). Boron is mobile in plants through xylem tissue directly to vegetative parts. Again, in case of broccoli head, highest boron concentration and uptake by broccoli head was found in combined application of boron soil @2kg/ha and zinc foliar application @0.5% (T8). Boron being in xylem tissue, adsorbed from soil as neutral molecules and accumulates in broccoli head. Combined application of boron and zinc resulted in enhanced vegetative growth, improved physical quality, and increased nutritional value of the broccoli heads **(Mahmoud *et. al*, 2019)**.

Table 5: Nutritional value (Zn and B content) of broccoli head as influenced by Zinc and boron with different application methods

Treatments		Zn conc. (%)			Zn uptake (kg/ha)			B conc. (%)			B uptake (kg/ha)		
		2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
T1		0.004	0.004	0.004	0.48	0.22	0.35	0.0014	0.0017	0.0016	0.09	0.1	0.09
T2		0.041	0.040	**0.041**	8.67	4.67	**6.67**	0.0019	0.0021	0.0011	0.24	0.29	0.26
T3		0.023	0.023	0.023	4.49	2.60	3.54	0.0016	0.0019	0.0017	0.16	0.23	0.19
T4		0.016	0.016	0.016	3.08	2.05	2.56	0.0032	0.0029	0.003	0.31	0.4	0.36
T5		0.015	0.015	0.015	2.73	2.09	2.41	0.0036	0.0039	0.0038	0.51	0.55	0.53
T6		0.011	0.012	0.012	2.15	1.59	1.87	0.004	0.0045	0.0042	0.53	0.6	0.57
T7		0.023	0.024	0.023	3.72	1.50	2.61	0.0018	0.0019	0.0019	0.1	0.1	0.1
T8		0.022	0.022	0.022	3.52	9.12	6.32	0.0047	0.0052	**0.0049**	2.2	2.32	**2.26**
T9		0.040	0.039	0.040	6.99	4.65	5.82	0.0023	0.0028	0.0026	0.3	0.25	0.27
Mean		0.02	0.022	0.022	3.98	3.17	3.57	0.0027	0.0051	0.0039	0.49	0.54	0.52
SEM	**B**	0.000	0.001	0.000	0.257	0.30	0.26	0.001	0.001	0.001	0.008	0.008	0.008
	Zn	0.000	0.001	0.000	0.257	0.30	0.26	0.002	0.001	0.001	0.008	0.007	0.008
	B X Zn	0.001	0.001	0.001	0.445	0.53	0.46	0.002	0.001	0.002	0.010	0.008	0.014
CD (0.05)	**B**	0.001	0.002	0.001	0.770	0.91	0.79	0.003	0.002	*	0.025	0.032	0.027
	Zn	0.001	0.002	0.001	0.770	0.91	0.79	*	*	*	*	*	*
	B X Zn	0.002	0.003	0.002	1.334	1.58	1.37	*	0.005	0.005	*	0.04	0.044
CV (%)		4.51	7.762	5.640	19.37	28.87	22.10	9.80	8.89	11.02	6.47	8.45	4.87

Treatments: T1: only recommended dose of fertilizer (control); T2:RDF+ zinc foliar @0.5%; T3: RDF+ zinc soil application @ 25kg/ha; T4: RDF+ boron foliar application @ 0.5%; T5: RDF + combined application of boron foliar @0.5% and zinc foliar @0.5%; T6: RDF + combined application of boron foliar @0.5% and zinc soil @25kg/ha; T7: RDF + boron soil application @2kg/ha; T8: RDF + combined application boron soil application @2kg/ha and zinc foliar @0.5%; T9: RDF + combined application for boron soil @2kg/ha + zinc soil @25kg/ha.Recommended dose of fertilizer: N: P_2O_5: K_2O::150:100:100 (kg/ha) were applied through urea, DAP and muriate of potash.

Conclusion:

In conclusion the combined application of boron in soil @2kg/ha and zinc as foliar @ 0.5% would enhance bioavailability of zinc and boron in broccoli head which is evident from growth parameters. Moreover, combined application of boron in soil and zinc as foliar would improve quality attributes in broccoli head. This would be an effective practice to increase nutrient concentration in broccoli head and consumption of broccoli would mitigate chances of cancer in human because of zinc.

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