J. Indian Soc. Coastal Agric. Res. 38(1): 50-56 (2020)

Influence of Boron and Zinc Nutrition on Yield, Nutrient Uptake, Recovery and Economics of Maize (*Zea mays*) Grown in a Coastal *Alfisol*

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Received: 24.07.2019 Accepted: 07.02.2020

Micronutrients play an important role in plant metabolism along with macronutrients and in augmenting crop yields. It accelerates the enzymatic activity in plant metabolism despite of its small requirement. Maize is an important crop in rice-maize cropping system in Odisha. Role of micronutrients in addition to macronutrients play a pivotal role in augmenting yield of maize. A field experiment was conducted during 2015 and 2016 in order to study the effect of boron (B) and zinc (Zn) nutrition along with recommended soil test based (STB) fertilization. The growth parameters, yield of the crop, nutrient uptake, apparent nutrient recovery and economics of maize were studied in a coastal *Alfisol* of Odisha. The experiment was laid out in a randomized block design (RBD) comprising of 10 treatments. Different growth parameters like days to silking (62), plant height (183 cm), cob length (29.9 cm), cob diameter (4.50 cm), rows per cob (17.20) and kernels per cob (588) were found highest in T_9, where both B and Zn were applied along with STB fertilization. Total harvested yield of maize including stover (2.80 to 3.24 t ha^{-1}), rachis (0.64 to 0.85 t ha^{-1}) and kernel (1.81 to 2.29 t ha^{-1}) varied from 5.25 to 6.38 t ha^{-1} in different treatments and was observed highest in T_9 (6.38 t ha^{-1}). Harvest index (49.28%), B:C ratio (2.46) and 100 kernel weight (22.80 g) were also recorded highest in treatment T_9. Uptake of nutrients like N, P, K, S, B and Zn were studied and there was a significant variation within the treatments. Apparent nutrient recovery of major nutrients like N (9.09%), P (10.62%) and K (40.17%) were calculated and observed best in T_9, where soil application of B and Zn were amalgamated with STB fertilization of NPK.

(***Key words:*** *Apparent nutrient recovery, Economics, Harvest index, Maize yield, Nutrient uptake*)

Among the cultivable soils of Odisha, nearly 75% are characterized with low pH (Jena, 2014) and low availability of N, P, S, Ca, Mg, etc. which indirectly affect the crop yield and total crop production of the state. Rice-maize system is one of the major cropping systems in Odisha. Due to scanty research work on micronutrients, particularly on its role in augmenting crop yield, this has been a major drawback in decreasing maize yield in Odisha. Maize popularly known as corn is one of the most versatile emerging cash crop of the state having wider adaptability under different agro climatic conditions of Odisha. Marketability of sweet corn in the country in general and in the state in particular is becoming more and more popular. Area and productivity of major corn clusters of Odisha are recorded as 1.15 lakh ha and 3031 kg ha^{-1} respectively (MSME 2017-18).

In Odisha, the average corn yield varies from 1.32 t ha^{-1} to 2.18 t ha^{-1} under different agroclimatic conditions and soil management practices. A productivity potential of 6.75 lakh MT (3.1% of India) is recorded in Odisha which is less than the national average (MSME 2017-18). An approach for giving fertilizer recommendations based on soil testing is a unique tool for rational fertilizer use. It helps to assess not only soil fertility status but also in augmenting the crop yield and economics by increasing the nutrient uptake by crop. Of the essential plant nutrient elements, micronutrients play a major role in plant metabolism and also act as plant growth regulators (Panda and Mandal, 2018). Though its requirement, use efficiency by crop and its uptake is less as compared to macronutrients, their role in crop metabolism is indispensable and it further increases the crop yield to the tune of 2-3% over macronutrients application only. In cereals like maize the role of Zn is very essential. It helps in different metabolic activities as a metallic cofactor in plant enzymatic activities (Havlin *et al*., 2016). Along with Zn, B is also important, as it helps in proper pollination and fruit setting (Havlin *et al*., 2016). Zn is sensitive to maize and its deficiency limits corn yield (Alloway, 2009). To develop a best

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package of practice (POP) for maize particularly in the coastal agroclimatic situation of Odisha to augment maize yield, nutrient uptake, recovery of nutrients and economics of maize, the present work was conducted considering STB fertilization in integration with micronutrients like B and Zn.

MATERIALS AND METHODS

A field experiment was conducted during 2015 and 2016 at Regional Research and Technology Transfer Station (RRTTS), Dhenkanal, Odisha, under Odisha University of Agriculture and Technology (OUAT), in order to study the effect of boron and zinc nutrition on growth, yield, nutrient uptake, apparent nutrient recovery and economics of maize in a coastal *Alfisol*. The total rainfall received during the crop growth period was 933 mm and the maximum and minimum temperature was 11.1°C and 32.7°C respectively. The experimental soil was analyzed by adopting standard methods (Page *et al*., 1982; Panda, 2019). The soil of the experimental site was sandy loam, acidic in reaction (pH 5.7), medium in available N, P and K. The initial characteristics of soil at the experimental site are furnished in Table 1. The experiment was conducted taking ten (10) treatments each replicated thrice in a randomized block design (RBD). The treatments were: T_1 - soil test based (STB) fertilization, T_2 - STB + soil application of boron (B) @ 0.5 kg ha^{-1}, T_3 - STB + soil application of B @ 1.0 kg ha^{-1}, T_4 - STB + soil application of B @ 0.5 kg ha^{-1} + foliar application of B @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil aplication of zinc (Zn) @ 2.5 kg ha^{-1}, T_6 - STB + soil application of Zn @ 5 kg ha^{-1}, T_7 - STB + soil application of Zn @ 2.5 kg ha^{-1} + foliar application Zn @ 0.3% twice at 30 and 60 DAS, T_8 - STB + foliar application of B and Zn @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of B @ 0.5 kg ha^{-1} and Zn @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of B @ 1.0 kg ha^{-1} and Zn @ 5 kg ha^{-1}. The source of boron and zinc were borax and $ZnSO_4$ respectively. The recommended NPK fertilizer dose for the crop was 120-60-60 kg as N-P_2O_5-K_2O per ha. Fertilizers were applied after adjusting the doses as per soil test based dose data through DAP, urea and MOP. Maize variety 'High Shell' was selected for this study. Net plot size of 4 m x 3.5 m with spacing of 50 cm x 25 cm was maintained and the crop was harvested after maturity. The maize kernels and stovers after harvest were air dried and weighed plot wise to record the yield data. Two plants from each plot were sampled for detailed chemical analysis. The kernels and stovers were kept separately in paper envelopes, labelled properly and dried in hot air oven at 60ºC. Each sample was ground separately with the help of a Willy Mill to pass through 20 mesh sieve and was used for analysis of different nutrient elements. As per the method outlined by Piper (1950), 1 g of ground grain sample was predigested with 20 ml of concentrated HNO_3 followed by digestion with 10 ml of diacid (HNO_3 : $HClO_3$) on hot plate at 100°C for analysis of elements like P, K, S, B and Zn. However, the element N was estimated by taking H_2SO_4 in place of HNO_3. After suitable dilution of the aliquot, the samples were analyzed by standard methods specific for particular nutrient element (Piper, 1950). From the nutrient content, uptake of nutrients were calculated by multiplying its value with the biomass or yield of the crop. Crop yield and nutrient analysis data were recorded and compiled. The B:C ratio was calculated considering the present rate of inputs and market value of the produce. The analysis of variance (ANOVA) of different variables under different treatments was statistically calculated (Panse and Sukhatme, 1985). The nutrient uptake, harvest index (HI) and apparent nutrient recovery (ANR) were calculated by adopting the formula given below (Pradhan *et al*., 2019).

Table 1. *Initial soil characteristics of the experimental site*

Parameters	Value
Sand (%)	78.3
Silt (%)	5.7
Clay (%)	16.0
Texture	Sandy loam
B.D. (Mg m^{-3})	1.57
pH	5.7
EC (dS m^{-1})	0.02
Organic Carbon (g kg^{-1})	6.0
Mineralizable N (kg ha^{-1})	260.0
Available Bray's P (kg ha^{-1})	19.0
Ammonium acetate K (kg ha^{-1})	190.0
CaCl2 extractable S (kg ha^{-1})	40.0
DTPA Extractable B (mg kg^{-1})	0.78
DTPA Extractable Zn (mg kg^{-1})	0.86

Nutrient Uptake (kg ha^{-1}) = Dry matter (q ha^{-1})) x Nutrient concentration (%) ... (1)

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (Grain+Straw yield)}} \quad \text{... (2)}$$

Apparent Nutrient Recovery (ANR) =

$$\frac{\text{Nutrient uptake in nutrient treated plot-Nutrient uptake in control}}{\text{Nutrient applied}} \times 100 \quad \text{.. (3)}$$

RESULTS AND DISCUSSION

Combined effect of B and Zn nutrition on growth and yield attributes in Maize

Growth and yield attributes are complex characters, which are the product of multiplicative interactions of a number of growth attributing components (Burtan and Devane, 2008). It cannot be improved to a greater extent without amalgamating the micronutrients with macronutrients (Panda and Mandal, 2018). Hence, to improve the growth and yield attributing characters of maize, proper integration of micronutrients like B and Zn with macronutrients was done. Data pertaining to impact of B and Zn nutrition on growth and yield attributing characters of the crop maize are depicted in Table 2. Variation in days to silking due to different treatments was non-significant and the crop took about 62 days for silking. The plant height varied from 171 to 183 cm, cob length varied from 26.8 to 29.9 cm, cob diameter varied from 3.8 to 4.5 cm, rows per cob varied from 16 to 17, kernels per cob varied from 488 to 588 and these parameters were found highest in T_9, where both B and Zn were applied to the soil in amalgamation with STB fertilization of NPK. The significant variation on th growth attributes as recorded in different treatments showed a positive influence of soil application of B and Zn in integration with NPK fertilization. Hence, soil application of B and Zn to a crop field leads to its proper transformation and availability to crops which results in higher growth and yield (Dugger, 1983; Prasad and Kumar, 1993; Tejpal *et al*., 2018).

Effect of B and Zn nutrition on kernel weight, yield, harvest index and economics of maize

Kernel weight (g), yield (t ha^{-1}), harvest index (HI) and economics of maize as influenced by nutrition B and Zn along with NPK fertilization are presented in Table 3. Application of micronutrients along with major nutrients enhances different growth as well as yield parameters in maize (Tejpal *et al*., 2018). In the present investigation proper management of macronutrient

Table 2. *Effect of boron and zinc nutrition on growth and yield attributing characters of maize*

Treatments	Days to silking	Plant height (cm)	Cob length (cm)	Cob dia. (cm)	Rows per cob	Filled grains per cob
T_1	61.67	171.44	26.80	3.80	16.20	488.00
T_2	61.00	173.60	27.00	4.00	16.30	494.00
T_3	61.33	174.00	26.40	3.60	16.70	504.00
T_4	61.33	178.00	27.10	3.50	16.00	528.00
T_5	61.33	174.00	27.80	4.30	15.60	512.00
T_6	61.67	179.00	28.80	4.00	15.60	534.00
T_7	61.33	181.40	28.50	3.80	15.80	562.00
T_8	61.33	183.00	29.20	4.40	16.80	579.00
T_9	62.00	183.60	29.90	4.50	17.20	588.00
T_{10}	61.67	180.00	29.00	4.40	15.50	574.00
SEM (±)	0.29	1.12	0.58	0.26	0.29	1.85
LSD (p=0.05)	NS	3.40	1.74	0.77	0.87	5.60

T_1 - soil test based (STB) fertilizer recommendation, T_2 - STB + soil application of boron @ 0.5 kg ha^{-1}, T_3 - STB + soil application of boron @ 1.0 kg ha^{-1}, T_4 - STB + soil application of boron @ 0.5 kg ha^{-1} + foliar application of boron @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil application of zinc @ 2.5 kg ha^{-1}, T_6 - STB + soil application of zinc @ 5 kg ha^{-1}, T_7 - STB + soil application of zinc @ 2.5 kg ha^{-1} + foliar application of zinc @ 0.3% twice at 30 and 60 DAS , T_8 - STB + foliar application of boron and zinc @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of boron @ 1.0 kg ha^{-1} and zinc @ 5 kg ha^{-1}

in amalgamation with micronutrients like B and Zn enhanced kernel weight upto 84.97% over STB fertilization of NPK. However, a significant variation to the kernel weight (g) of maize was recorded in different treatments which varied from 6.92 to 12.80 g and was found highest in T_9, where both B and Zn were applied to soil in amalgamation with STB fertilization of NPK.

The yield variability is a key to crop improvement and its productivity (Matias *et al*., 2016). Zn is commonly applied in physical blending with other macronutrients. Hence in the present study B is blended with Zn and other macronutrients to gather knowledge on yield performance of crop maize. It was observed that proper amalgamation of macro (N, P & K) and micronutrients (B, Zn) could enhance the yield of maize in different treatments. Hence, a significant stover, rachis and grain yield of crop maize was observed in different treatments over STB fertilization of NPK and it varied from 2.80 to 3.24 t ha^{-1}, 0.64 to 0.85 t ha^{-1} and 1.81 to 2.29 t ha^{-1} respectively in different treatments. Better response was recorded in T_9 where B and Zn were applied to soil in integration with NPK fertilization. Total harvested yield of maize (including stover, rachis and grain) varied from 5.25 to 6.38 t ha^{-1} in different treatments and observed highest in T_9 (6.38 t ha^{-1}). The per cent yield advantage in different treatments over treatment T_1 (STB fertilization) varied from 2.35 to 18.67 and highest was recorded in T_9 where both B and Zn were applied to the soil in amalgamation with STB fertilization of NPK. Maize crop is susceptible to low Zn and corn cultivars applied with required doses of Zn enhanced the translocation and utilization of Zn in plants (Havlin *et al*., 2016). The crop is also less sensitive to B deficiency (Havlin *et al*., 2016); hence application of B with Zn and other nutrients could enhance the yield of the crop (Matias *et al*., 2016). Diffusion and root interception are the mechanisms by which Zn comes into contact with plant roots and B by mass flow (Marschner and Rengel, 2012). The reason for the greater yield with the macronutrients physically blended with Zn and B may due to the greater use efficiency and uptake of nutrients by crop maize.

Harvest index (HI) is the ratio of economic (kernel) yield to the total biomass (kernel + stover). It indicates

Table 3. *Effect of boron and zinc nutrition on kernel weight, yield, HI and economics of maize*

Treatments	100 Kernel wt. (gm)	Yield (t ha^{-1})					HI (%)	B:C ratio
		Stover	Rachis	Kernel	Total	Per cent yield advantage (over control)		
T_1	16.92	2.80	0.64	1.81	5.25	-	46.68	2.10
T_2	17.05	2.84	0.66	1.88	5.38	2.35	47.20	2.10
T_3	18.70	2.87	0.66	1.89	5.42	3.12	47.04	2.08
T_4	19.48	2.91	0.67	1.90	5.48	4.31	46.86	2.09
T_5	19.32	2.94	0.69	1.99	5.62	6.83	47.66	2.10
T_6	19.75	3.06	0.73	2.06	5.85	10.73	47.76	2.24
T_7	19.91	3.07	0.74	2.10	5.91	11.39	48.07	2.18
T_8	21.32	3.17	0.76	2.13	6.06	13.84	47.68	2.30
T_9	22.80	3.24	0.85	2.29	6.38	18.67	49.28	2.46
T_{10}	10.95	3.19	0.77	2.20	6.16	14.32	48.20	2.34
SEM (+)	0.11	0.06	0.006	0.018				
LSD (p=0.05)	0.31	0.19	0.018	0.053				

T_1 - soil test based (STB) fertilizer recommendation, T_2 - STB + soil application of boron @ 0.5 kg ha^{-1}, T_3 - STB + soil application of boron @ 1.0 kg ha^{-1}, T_4 - STB + soil application of boron @ 0.5 kg ha^{-1} + foliar application of boron @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil application of zinc @ 2.5 kg ha^{-1}, T_6 - STB + soil application of zinc @ 5 kg ha^{-1}, T_7 - STB + soil application of zinc @ 2.5 kg ha^{-1} + foliar application of zinc @ 0.3% twice at 30 and 60 DAS , T_8 - STB + foliar application of boron and zinc @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of boron @ 1.0 kg ha^{-1} and zinc @ 5 kg ha^{-1}

the efficiency of plant to assimilate photosynthates to the economic parts, higher the HI more will be the deposit of assimilates in plant maize (Epstein, 1956). In the present study HI of the maize crop due to different treatments varied from 46.68 to 49.28% and a numerical higher value was recorded in treatments T_9 (49.28%). The economics of the treatments is presented in Table 3. Economics depends on cost of cultivation up to the stage of harvest and the cost of produce that include factor costs up to the stage of marketing of the produce. It reflects the best nutrient management practices with low cost of cultivation that enhances the crop yield. The present study revealed that B:C ratio in different treatments varied from 2.10 to 2.46. However, taking maize crop into consideration, better economics of this experiment was recorded in T_9 (2.46) where soil application of B and Zn was applied in integration with NPK fertilization.

After harvest of the crop the kernels were used to study the nutrient uptake pattern. Uptake of nutrients like N, P, K, S, B and Zn were studied in this experiment and are reflected in Tables 4 and 5. From different plots uptake of nutrients by maize grain was studied. It was observed that uptake of N by maize varied from 20.74 to 34.08 kg ha^{-1} whereas other nutrients like P varied from 4.72 to 9.17 kg ha^{-1}, K varied from 9.89 to 19.18 kg ha^{-1}, S varied from 1.05 to 3.10 kg ha^{-1}, B varied from 0.6 to 0.98 kg ha^{-1} and Zn varied from 0.31 to 0.65 kg ha^{-1}. It was also recorded that uptake of different nutrients by stover varied from treatment to treatment. The uptake of N by maize stover varied from 22.39 to 33.30 kg ha^{-1} whereas other nutrients like P varied from 4.51 to 6.43 kg ha^{-1}, K varied from 37.64 to 54.11 kg ha^{-1}, S varied from 3.64 to 9.26 kg ha^{-1}, B varied from 0.15 to 1.13 kg ha^{-1} and Zn varied from 0.33 to 0.76 kg ha^{-1}. However the uptake of each nutrient element was recorded highest in treatment T_9. Apparent nutrient recovery (ANR) of major nutrients in crop maize was estimated and it varied in different treatments. Data pertaining to ANR of nutrients in maize are depicted in Table 6. ANR of N varied from 1.40 to 9.09%, P varied from 0.82 to 10.62% and K varied from 0.58 to 40.17% in different treatments. The highest ANR of all these macronutrients elements were observed best with treatment T_9, where soil application of Zn and B were amalgamated with STB fertilization of NPK. As ANR reflects plant ability

Table 4. *Effect of boron and zinc nutrition on nutrient uptake by maize kernel*

Treatments	Nutrient uptake by grain (kg ha^{-1})					
	N	P	K	S	B	Zn
T_1	20.74	4.72	9.89	1.05	0.16	0.31
T_2	22.28	5.00	10.01	1.49	0.29	0.46
T_3	23.66	5.22	10.82	1.64	0.29	0.48
T_4	24.21	5.64	12.23	2.00	0.37	0.50
T_5	25.65	6.19	13.39	2.25	0.42	0.54
T_6	26.97	6.46	15.13	2.41	0.49	0.55
T_7	27.45	6.75	15.68	2.58	0.50	0.58
T_8	29.26	7.54	16.55	2.67	0.82	0.59
T_9	34.08	9.17	19.18	3.10	0.98	0.65
T_{10}	29.61	7.34	17.52	2.80	0.78	0.62
SEM (±)	0.39	0.18	0.05	0.02	0.03	0.01
LSD (p=0.05)	1.17	0.47	0.14	0.07	0.09	0.03

T_1 - soil test based (STB) fertilizer recommendation, T_2 - STB + soil application of boron @ 0.5 kg ha^{-1}, T_3 - STB + soil application of boron @ 1.0 kg ha^{-1}, T_4 - STB + soil application of boron @ 0.5 kg ha^{-1} + foliar application of boron @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil application of zinc @ 2.5 kg ha^{-1}, T_6 - STB + soil application of zinc @ 5 kg ha^{-1}, T_7 - STB + soil application of zinc @ 2.5 kg ha^{-1} + foliar application of zinc @ 0.3% twice at 30 and 60 DAS , T_8 - STB + foliar application of boron and zinc @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of boron @ 1.0 kg ha^{-1} and zinc @ 5 kg ha^{-1}

Table 5. *Effect of boron and zinc nutrition on nutrient uptake by maize stover*

Treatments	Nutrient uptake by stover (kg ha^{-1})					
	N	P	K	S	B	Zn
T_1	22.39	4.51	37.64	3.64	0.15	0.33
T_2	24.07	4.72	37.87	3.88	0.37	0.59
T_3	25.37	5.06	39.30	4.30	0.31	0.61
T_4	25.93	5.73	40.50	5.54	0.40	0.62
T_5	26.86	5.71	41.80	6.18	0.45	0.62
T_6	28.08	5.84	45.25	7.03	0.64	0.67
T_7	27.80	6.08	47.61	7.68	0.63	0.67
T_8	30.60	6.30	49.10	7.94	0.80	0.71
T_9	33.30	6.43	54.11	9.26	1.13	0.76
T_{10}	31.71	6.34	49.68	8.09	0.98	0.72
SEM (±)	0.49	0.07	0.76	0.22	0.06	0.01
LSD (p=0.05)	1.47	0.22	2.27	0.66	0.19	0.02

T_1 - soil test based (STB) fertilizer recommendation, T_2 - STB + soil application of boron @ 0.5 kg ha^{-1}, T_3 - STB + soil application of boron @ 1.0 kg ha^{-1}, T_4 - STB + soil application of boron @ 0.5 kg ha^{-1} + foliar application of boron @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil application of zinc @ 2.5 kg ha^{-1}, T_6 - STB + soil application of zinc @ 5 kg ha^{-1}, T_7 - STB + soil application of zinc @ 2.5 kg ha^{-1} + foliar application of zinc @ 0.3% twice at 30 and 60 DAS , T_8 - STB + foliar application of boron and zinc @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of boron @ 1.0 kg ha^{-1} and zinc @ 5 kg ha^{-1}

Table 6. *Effect of boron and zinc nutrition on apparent nutrient recovery (ANR) in maize*

Treatments	Apparent nutrient recovery (%)		
	N	P	K
T_1	-	-	-
T_2	1.40	0.82	0.58
T_3	2.48	1.75	4.32
T_4	2.95	3.57	8.67
T_5	3.73	4.45	12.77
T_6	4.74	5.12	21.42
T_7	4.51	6.00	26.27
T_8	6.84	7.68	30.20
T_9	9.09	10.62	40.17
T_{10}	7.77	7.42	35.55

T_1 - soil test based (STB) fertilizer recommendation, T_2 - STB + soil application of boron @ 0.5 kg ha^{-1}, T_3 - STB + soil application of boron @ 1.0 kg ha^{-1}, T_4 - STB + soil application of boron @ 0.5 kg ha^{-1} + foliar application of boron @ 0.3% twice at 30 and 60 DAS, T_5 - STB + soil application of zinc @ 2.5 kg ha^{-1}, T_6 - STB + soil application of zinc @ 5 kg ha^{-1}, T_7 - STB + soil application of zinc @ 2.5 kg ha^{-1} + foliar application of zinc @ 0.3% twice at 30 and 60 DAS , T_8 - STB + foliar application of boron and zinc @ 0.3% twice at 30 and 60 DAS, T_9 - STB + soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1}, T_{10} - STB + soil application of boron @ 1.0 kg ha^{-1} and zinc @ 5 kg ha^{-1}

to acquire applied nutrients from soil pool, it was summarized that application of nutrients like B and Zn to soil along with NPK fertilizers enhances uptake of macronutrients as well as crop yield. This could be possible because of the presence of micronutrients like Zn, that accelerates the enzymatic activities as a metallic group in plant cell and B which increases the cell functions and thus enhanced the crop yield (Rattan *et al*., 1997). In cereals like maize, Zn accelerates the enzymes like carbonic anhydrase, superoxide dismutase and alcoholic dehydrogenase. Hence application of Zn could enhance the biochemical pathways and synthesis of biomolecules in maize which leads to enhanced nutrient uptake and yield augmentation (Alloway, 2009).

From the present study, it could be concluded that application of NPK fertilizers along with micronutrients like B and Zn could enhance the growth as well as yield parameters of maize in coastal agroclimatic situations of Odisha. Further it could be summarized that B:C ratio, harvest index, nutrient uptake and apparent nutrient recovery can also be enhanced through soil application of B and Zn in amalgamation with NPK fertilizers. Of the treatments taken in this experiment, treatment T_9

where soil test based (NPK) fertilizers along with soil application of boron @ 0.5 kg ha^{-1} and zinc @ 2.5 kg ha^{-1} were applied had the best result over other treatments.

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