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AGRONOMY

Response of Boron on Yield and Economics of Maize under Eastern Ghat High Land Zone of Odisha

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ABSTRACT

A field experiment was conducted in participatory mode on farmers' field in Sankumari village of Nabarangpur district under Eastern Ghat High Land (EGHL) zone of Odisha during *kharif* 2016 to assess the response of boron application on yield and economics of maize. The experiment was laid out in Randomized Block Design with four treatments replicated five times. The experimental soils were slightly acidic, non-saline, loamy sand, medium in organic carbon and available K; low in available N, P, B and Zn contents. The maximum grain yield per cob (210.21 g),100 seeds weight (38.16 g), stover yield (8.10 t ha^{-1}), grain yield (6.52 t ha^{-1}), total dry biomass (14.62 t ha^{-1}), harvest index (44.59%) and B:C ratio (1.90) were recorded in Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} soil application + 0.2 % borax as foliar spray at 30 & 45 DAS (T_4) followed by Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1}(T_3) over control (i.e. Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1}+ 0 kg B ha^{-1}). Hence, Soil Test Based fertilizer application with boron is to be followed in soil deficient in boron under continuous maize growing areas of EGHL zone of Odisha for remunerative maize production by the farmers.

Highlights

- Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} soil application + 0.2 % borax as foliar spray at 30 & 45 days after sowing (DAS) in maize is profitable and it improves productivity.

Keywords: Maize,boron, economic yield, economics

Maize (*Zea mays* L.) is the third important cereal crop next to rice and wheat in the world. Maize has been an important cereal crop because of its high production potential compared to any other cereal crop and better adaptability to wide range of environments. Since, the crop has very high genetic yield potential, it is called as the "Queen of cereals". Maize being a C_4 plant has higher yield potential which also depends on nutrient supplying capacity of the soil. However, its potential could not be utilized fully due to lack of proper nutrient management practices (Sahrawat *et al.* 2008). It is cultivated in all the soil types (except in sandy soil) and agro-climatic conditions. Being a photo insensitive crop, maize has been adopted in different seasons and in different regions, with crop duration ranging from <90-130 days (Humtsoe 2018). In India, it is cultivated over an area of 92.32 lakh hectares with an annual production of 236.73 lakh tonnes having an average productivity of more than 2564 kg ha^{-1} (Borase *et al.* 2018). In Odisha, it occupies an area of 2.80 lakh hectares with total productions of

7.79 lakh tones having an average productivity of 2.78 tha^{-1} in 2013-14 (Odisha Agriculture Statistics, 2013-14, Directorate of Agriculture and Food production, Odisha, www.agriodishanic.in). The state of Odisha covering geographical area of 15.57 m ha lies in the tropical belt in the eastern region of India between 170.47'-220 33' N latitude and 810 31'-87030' E longitudes. The climate is characterized by high temperature and medium rainfall. The average annual rainfall of the state is 1500 mm and the mean annual temperature is 26.2°C. The soils are deficient in nitrogen, phosphorus and micronutrients like boron and molybdenum are highly deficient in these soils (Sahu and Mishra 2005). About 44 percent of soils of Odisha are deficient in B (Jena *et al.* 2008). Micronutrient deficiency is one of the major causes of the declining crop productivity trends because of the escalated nutrient demand from the more intensive and exploitative agriculture (Alloway, 2008). Maize has been previously considered to have a relatively low boron (B) requirement compared with other cereals (Marten and Westermann 1991). Deficiency of B in field grown maize was first observed in the 1960s in the United States (Shorrocks and Blaza 1973), and yield increase of more than 10% were observed in response to B application (Woodruff *et al.* 1987). In B deficient maize, poor grain setting can result in barren cobs, and this was attributed by Vaughan (1977).

With this information, the present investigation has been undertaken to assess the response of boron application on yield and economics of maize on alfisol under Eastern Ghat High Land zone (EGHZ) of the Odisha.

MATERIALS AND METHODS

Characterization of experimental site

A field experiment was conducted in participatory mode on farmers' field in Sankumari village of Nabarangpur district under Eastern Ghat High Land Zone (EGHLZ) of Odisha during *kharif*-2016. The field is situated at 19°38'27.68'' N latitude, 82°10'20.07" E longitude, experiencing warm and humid climate with mean annual rainfall of 1210 mm, minimum and maximum temperature of 12 °C and 40 °C, respectively. The soil was *Typic Haplustalfs* with loamy sand texture, slightly acidic in reaction. The experimental soils were slightly acidic (pH- 5.95), non-saline (EC- 0.06 dS m^{-1}), loamy sand in texture, medium in organic carbon (5.2 g kg^{-1}), available K (140.0 kg ha^{-1}), and low in available N (190.0 kg ha^{-1}), available P (11.0 kg ha^{-1}), available B (mg kg^{-1}) and available Zn (mg kg^{-1}) contents, respectively.

Experimental details

The experiment was laid out in Randomized Block Design with four treatments replicated five times taking maize (cv. Kaveri, 25K55) as test crop. The detail treatments were, T_1: Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0 kg B ha^{-1} soil application, T_2: Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} soil application, T_3: Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1} soil application and T_4: Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} soil application + 0.2 % borax as foliar spray at 30 & 45 DAS. Soil Test Based NPKZn NPKZn @ 150:75:60:6.25 kg ha^{-1} application was done in which 25% more N, P and Zn were applied basing upon the normal Recommended dose of fertilizer (i.e. NPKZn @ 120:60:60:5 kg ha^{-1}). The entire amount of P and K were applied as basal during final land preparation (before sowing). Nitrogen was applied in 3 split doses, 25% as basal, 50% at first hoeing (3 weeks after sowing) and 25% at second hoeing (6-7 weeks after sowing).

Top dressings of fertilizers were applied at the time of hoeing/intercultural and earthing up operations to incorporate fertilizer into the soil. Borax fertilizer was applied as basal soil application during sowing prefers mixed with FYM @ 5 t ha^{-1} in each respective treatment except control and foliar spray of B as borax was applied at 30 and 45 days after sowing. The maize was sown during third week of June. All the other cultural practices were followed uniformly throughout the growing period of crop. The observations data of maize were recorded at harvest and grain yield was recorded at 14% moisture content. The economics of maize cultivation was calculated basing upon the prevailing market prices of the local area where experiment was conducted.

Analytical methodologies

A composite soil sample was analyzed for physico-chemical properties before conducting the

Table 1: Analytical methodologies for different soil parameters

Parameter	Methodology	Citation	Equipment used
		Soil analyses	
Sand-Silt-Clay	Hydrometer method	Bouyoucos (1962)	Hydrometer
pH	(in 1:2.5:: Soil : Water)	Jackson (1967)	m-processor based pH-EC-Ion meter
EC	(in 1:2.5:: Soil : Water)	Jackson (1967)	m-processor based pH-EC-Ion meter
Organic carbon	Wet oxidation method	Jackson (1973)	
Available N	Hot alkaline $KMnO_4$ Method	Subbiah and Asija (1956)	Kjeldahl apparatus
Available P	0.03 N NH_4F + 0.025 N HCL (pH 3.5)	Bray and Kurtz (1945)	Spectrophotometer
Available K	Neutral N NH_4OAc extraction	Brown and Warncke (1988)	Flame photometer
Available B	Hot water extraction	Berger and Truog (1939)	Spectrophotometer
Available Zn	DTPA extraction	Lindsay and Norvell (1978)	Atomic Absorption Spectrophotometer

Table 2: Effect of boron application on yield attributes, yield and harvest index of maize

Treatments	Grain yield per cob (g)	100 seeds wt. (g)	Yield (t ha^{-1})			HI (%)
			Grain	Stover	Total dry biomass	
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0 kg B ha^{-1}	180.12	32.17	4.72	6.82	11.54	40.90
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1}	190.10	35.57	5.67	7.52	13.19	42.98
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1}	196.60	37.86	6.06	7.83	13.89	43.62
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} + 0.2 % B (Borax) foliar spray at 30 & 45 DAS	210.21	38.16	6.52	8.10	14.62	44.59
SEm (±)	1.088	0.871	0.088	0.057	0.099	—
CD (p = 0.05)	3.353	2.685	0.271	0.174	0.305	—
CV (%)	1.253	5.422	3.426	1.673	1.664	—

DAS: Days after sowing.

experiment. The method involved in analyses of initial soil samples is depicted (Table 1).

Statistical interpretation

The data were analyzed statistically by the analysis of variance technique using SPSS (version 18.0, Chicago, USA).

RESULTS AND DISCUSSION

Effect on yield attributes of maize

The data depicted in Table 2 indicated that maximum grain yield per cob (210.21 g) and 100 seeds weight (38.16 g) were observed in Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} + 0.2 % B (Borax) foliar spray at 30 & 45 DAS (T_4) which was higher than all other treatments followed by Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1}(T_3). It corroborated with the findings of Parasuraman *et al.* (2008) and Borase *et al.* (2018).

Effect on yield of maize

The grain yield (6.52 t ha^{-1}), stover yield (8.10 t ha^{-1}), total dry biomass (14.62 t ha^{-1}) and harvest index (44.59 %) were found significantly highest (Table 2) in Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} + 0.2 % B (Borax) foliar spray at 30 & 45 DAS (T_4) which was higher than all other treatments followed by Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1} (T_3). Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} + 0.2 % B (Borax) foliar spray at 30 & 45 DAS (T_4) was increased

Table 3: Economics of maize cultivation

Boron doses	Production cost, INR ha^{-1}	Income INR ha^{-1}	Benefit, INR ha^{-1}	Income per INR investment
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0 kg B ha^{-1}	44364	69400	25035	1:1.56
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1}	45224	75122	29898	1: 1.66
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 1.0 kg B ha^{-1}	46084	80286	34202	1: 1.74
Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + 0.5 kg B ha^{-1} + 0.2 % B (Borax) foliar spray at 30 & 45 DAS	45568	86439	40871	1: 1.90

Notes: *Cost of hybrid seed, INR 360.00 kg^{-1}; Urea, INR 6.40 kg^{-1}; DAP, INR 24.00 kg^{-1}; MOP, INR 14.00 kg^{-1}; Borax, INR 172.00 kg^{-1}; Zinc Sulphate, INR 55.00 kg^{-1}; Labour wages, INR 200.00 $M.U^{-1}$; Selling price: INR 13.25 kg^{-1} seed; INR: Indian Rupee.*

grain yield by 38.14% over control (i.e. Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1}+ 0 kg B ha^{-1}). Similar results were reported by Parasuraman *et al.* (2008); Soomro *et al.* (2011) and Borase *et al.* (2018). Tahir *et al.* (2012) observed that the improvement in grain, stover and biological yield of maize is mainly attributed to complementary role of boron in the reproduction and vegetative stage of plants.

Economics of Maize Cultivation

The production cost of maize (Table 3) varied between ₹ 44364 ha^{-1} to ₹ 45568 ha^{-1}. Highest income (₹ 86439.00) and profit (₹ 40871.00) per ha was obtained in the T_4 (Soil Test Based NPKZn @ 150:60:60:6.25 kg ha^{-1} + B @ 0.5 kg ha^{-1} + 0.2 % borax as foliar spray at 30 & 45 DAS). The benefit cost ratio (B:C) varied from 1.56 to 1.90 and highest B:C ratio was found in the treatment T_4 (Soil Test Based NPKZn @ 150:60:60:6.25 kg ha^{-1} + B @ 0.5 kg ha^{-1} + 0.2 % borax as foliar spray at 30 & 45 DAS) followed by T_3 (Soil Test Based NPKZn @ 150:60:60: 6.25 kg ha^{-1} + B @ 1.0 kg ha^{-1}) over control (i.e. Soil Test Based NPKZn @ 150:60:60: 6.25 kg ha^{-1} + 0 kg B ha^{-1}). Humtsoe *et al.* (2018) also obtained the maximum economics with combined use of NPK @ 150:75:60 kg ha^{-1} + Zn @ 25 kg ha^{-1} as basal and B @ 0.3% as foliar spray in maize.

CONCLUSION

It is concluded that Soil Test Based NPKZn @ 150:75:60:6.25 kg ha^{-1} + boron as soil application @ 0.5 B kg ha^{-1} as basal along with foliar application @ 0.2% borax foliar spray at 30 & 45 DAS recorded highest grain yield (6.52 t ha^{-1}) and benefit (₹ 40,871) among the all treatments. Hence, Soil Test Based fertilizer application with boron is to be followed in soil deficient in boron under continuous maize growing areas of EGHL zone of Odisha for remunerative maize production by the farmers.

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