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Effect of sources, levels and methods of boron application on dry matter production, yield attributes and yield of maize (*Zea mays* L.) in inceptisol

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Abstract : Field experiment was conducted during 1998-2000 on soil deficient in available boron (0.35 mg kg^{-1}) at Agricultural Research Station, Bhavanisagar to study the comparative efficacy of Agribor as a source of boron on dry matter production, yield attributes and yield of maize crop. Four levels of boron (0.5, 1.0, 1.5, 2.0 kg B ha^{-1}) including foliar spray of 0.2% and 0.3% through two sources viz., borax (soil) and boric acid (foliar) [S_1] and Agribor [S_2] were tried. A significant response was obtained to B application on dry matter production, yield attributes and yield of maize at the level of 2kg B ha^{-1} followed by 1.5 kg B ha^{-1}. Foliar application also significantly increased the yield of maize over control. On comparing the sources of boron, Agribor was found to be effective in influencing the yield of maize.

Key words : Boron nutrition, dry matter production, yield attributes and yield of maize.

Introduction

Boron is an essential element for plant growth and yield. B deficiency is common and mostly seen in coarse textured soils. Response of B to oilseed crop has been reported (Shinde *et al*., 1990). Little information exists on the response of cereal crop to B. Among the cereals, maize is relatively more susceptible to B deficiency (Agarwala and Sharma, 1979). Boron also plays an important role in increasing the grain fruiting in maize as stated by Yiying Li and Hong Liang (1997). So the present investigation examines the effect of sources, levels and method of B application on the dry matter production, yield attributes and yield of maize.

Materials and methods

The field experiment was conducted in a Typic Ustropepts soil deficient in boron (HWS-B 0.35 ppm) at Agricultural Research Station, Bhavanisagar in Randomized Block Design (RBD) with three replications, with maize var Co^{-1} as test crop to study the effect of boron on dry matter production, yield attributes and yield of maize. Graded levels of B *viz*, 0 (T_1), 0.5 (T_2), 1.0 (T_3), 1.5 (T_4) and 2.0 (T_5) kg B ha^{-1} including foliar spray of 0.2 (T_6) and 0.3 (T_7) per cent with two sources of B namely borax and boric acid (S_1) and Agribor (S_2) [Having 19 per cent B and reported to be suitable both for soil and foliar application] were studied. The treatment details are presented in Table 1. The composition and properties of Agribor is as detailed below.

Chemical Formula	-	$Na_2 B_{10}O_{16}$, 10 H_2O
pH	-	6.5-7.5 at 3% solution
Solubility	-	100% soluble
Suitability	-	Both for soil and foliar application
Specific gravity	-	400 kg M^{-3}
Manufacturer	-	M/s Borax Morarji Ltd., Mumbai

The experimental soil was sandy loam in texture having pH of 7.2, E.C of 0.34 dSm^{-1}, low in available N (270 kg ha^{-1}) and medium in available P (20.5 kg ha^{-1}) and available K (225 kg ha^{-1}).

The maize seeds were sown after applying N, P and K (135, 62.5 and 50 kg N, P and K ha^{-1}) basally in the form of Urea, DAP and MOP. Soil application of the boron fertilizers were applied

basally in the form of Borax (S_1) and Agribor (S_2). The foliar sprays were given 30 DAS at 10 days interval in the form of boric acid (S_1) and Agribor (S_2). Necessary plant protection measures were taken. Dry matter production was calculated at three stages *viz* vegetative (stage-1), flowering (stage-2), and harvest (stage-3). At harvest stage length of cob, number of grains per cob, 100 seed weight and grain yield were recorded. The data were statistically analyzed and presented.

Results and Discussion

Dry Matter Production

The dry matter production was significantly influenced by B levels, stages and sources. The highest value (75.0 q ha^{-1}) was associated with T_5 (2 kg B ha^{-1}) and the lowest value (65.6 q ha^{-1}) was recorded in control (T_1). There was a linear increase in DMP with stages of maize crop. A significant variation was also observed between the two sources of B and it ranged from 68.7 q ha^{-1} (S_1) to 69.8 q ha^{-1} (S_2) (Table - 1).

The favourable influence of B on dry matter production may be due to the enhanced availability of B in the soil that plays a significant role in growth attributes which in turn influences dry matter production. The increase in dry matter production with the addition of B was also observed by Bhilegaonkar *et al.*, (1995). The performance of Agribor in influencing the dry matter production was consistently better than borax (soil) and boric acid (foliar) because the product Agribor dissolves more quickly than borax and boric acid.

Yield Attributes

The results for yield attributes (Table 2) indicated that the beneficial effect of B in influencing the length of cob, number of grains as well as 100 seed weight was observed in this study.

Application of 2 kg B ha^{-1} followed by 1.5 kg B ha^{-1} to the soil showed a profound effect in increasing the yield attributes. With regard to foliar spray 0.2 and 0.3 per cent were on par and registered higher values for length of cob, number of grains as well as 100 seed weight.

Table 1. Effect of sources, levels and methods of B application on drymatter production (q ha^{-1})

(Mean of three replications)

Treatment	Stage 1			Stage 2			Stage 3			Grand
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	
T_1	18.2	18.8	18.5	69.7	70.8	70.3	109	108	108	65.6
T_2	18.7	19.1	18.9	71.7	72.6	72.2	109	111	110	67.1
T_3	20.7	22.2	21.5	73.2	74.1	73.7	112	114	113	69.5
T_4	22.5	23.1	22.8	74.8	74.9	74.9	113	116	115	70.8
T_5	23.9	24.7	24.3	80.1	81.6	80.9	118	122	120	75.0
T_6	18.7	19.0	18.9	71.7	72.1	71.9	113	117	115	68.5
T_7	18.9	19.7	19.3	71.8	72.3	72.1	114	117	115	68.9
Mean	20.2	20.9	20.6	73.3	74.1	73.7	113	115	114	

	T	S	St	T x S	T x St	S x St	T x S x St
SEd	0.52	0.28	0.35	0.74	1.09	0.48	1.28
CD (P=0.05)	1.04	0.56	0.69	NS	NS	NS	NS

Table 2. Effect of sources, levels and methods of B application on Maize : Length of cob (cm), number of grains and 100 seed weight (g)

(Mean of three replications)

Treatment	Length of cob			Number of grains			100 seed weight		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	17.1	17.0	17.1	413	415	414	21.0	21.0	21.0
T_2	17.2	17.2	17.2	415	423	419	21.2	21.2	21.2
T_3	17.3	17.4	17.4	423	428	426	21.3	21.3	21.3
T_4	18.2	18.5	18.4	435	440	438	21.4	21.9	21.7
T_5	18.8	19.5	19.2	448	460	545	22.3	23.5	22.9
T_6	17.4	17.5	17.5	428	435	432	20.9	21.4	21.2
T_7	18.1	18.3	18.2	435	439	437	21.5	21.8	21.7
Mean	17.7	17.9	17.8	428	434	43.1	21.4	21.7	21.6
	T	S	TxS	T	S	TxS	T	S	TxS
SEd	0.05	0.03	0.07	5.84	3.16	8.26	0.21	0.11	0.29
CD (P=0.05)	0.10	0.05	0.15	12.0	6.51	NS	0.43	0.23	NS

As boron is reported to be involved in reproductive process and development of grain (Nyomora *et al.*, 1997) there are ample chances for the development of more grains on a cob occupying the entire length with grains which was observed in the present investigation.

Increase in 100 seed weight due to B application might be due to the enhanced uptake and translocation of sugar and is also implicated in carbohydrate metabolism (Mitra and Jana, 1991).

Between the two sources, Agribor showed its superiority over borax and boric acid by registering higher values for the yield attributes.

Grain yield

The grain yield of maize was found to increase by both soil as well as foliar application of boron (Table 3). Among the boron levels, application of 2 kg B ha^{-1} resulted in maximum grain yield (62.4 q ha-) followed by 1.5 kg B ha-1 (59.7 q ha^{-1}). The foliar treatments of 0.2% and 0.3% exhibited no significant difference between them. The tune of increase was 7.5 and 10.3 per cent over control for 1.5 and 2.0 kg B ha^{-1} respectively and to the tune of 5.57 per cent and 6.13 per cent for 0.2 and 0.3 per cent boron respectively. The marked response in grain yield of maize due to B application may be attributed to deficiency of B in the experimental soil (Sakal *et al.*, 1988). Also B application increased the grain fruiting in maize (reduced empty ears) as stated by Yiying Li and Hong Liang in maize (1997). The increase in the length of cob, number of grains per cob and 100 seed weight obtained due to B fertilization might have contributed for the increased grain yield over control. Moreover B fertilization or otherwise the correction of B deficiency apart than in influencing the uptake of nutrients *viz* N,P,K, Zn, Cu, Fe, Mn and B was also helpful in increasing the maize yield. Increased yield by boron application was also reported by Rai and Dighe (1971), Sakal *et al.*, (1989) and Sinha *et al.*, (1991).

Application of Agribor to the soil as well as to the foliage was proved to be better as compared to the conventionally used sources viz borax and boric acid.

Table 3. Effect of sources, levels and methods of B application on Maize : Grain and straw yield (q ha^{-1})

(Mean of three replications)

Treatment	Grain yield			Straw yield		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	56.6	56.5	56.5	109	108	108
T_2	56.4	57.5	56.9	109	111	110
T_3	57.9	58.0	58.0	112	114	113
T_4	59.9	61.6	60.8	113	116	115
T_5	61.5	63.2	62.4	118	122	120
T_6	59.4	59.9	59.7	113	117	115
T_7	60.0	60.0	60.0	114	117	115
Mean	58.8	59.5	59.2	113	115	114

	T	S	T x S	T	S	T x S
SEd	4.07	2.17	5.76	1.41	7.54	1.99
CD (P=0.05)	2.89	1.54	NS	8.37	4.47	NS

Straw yield

As in the case of maize grain yield, application of boron also increased the straw yield (Table 3). Among the levels of B, here again the application of 2.0 kg followed by 1.5 kg B ha^{-1} resulted in higher straw yield than control. Between the sources of B, Agribor (S_2) showed superiority over borax and boric acid (S_1).

The above result has been possible due to increase in the available boron content with corresponding increase in the level of B fertilization. The beneficial role of B in influencing straw yield through its role in the bio-synthesis of cell wall is an established fact (Kouchi, 1977) and also in the present investigation the positive influence of B on the growth attributes was seen right from vegetative to harvest stage.

Optimization of boron application through economic analysis and response ratio

The yield data indicated that the combination of 100 per cent N, P, K with soil application of boron at 2 kg ha^{-1} exhibited an equal effect of 1.5 kg B ha^{-1} along with NPK. Hence to fix the optimum level of B with N, P, K fertilizers, economic analysis has been worked out on cost - benefit ratio and response ratio.

From the economic analysis among the treatments, the combined application of 100 per cent N, P, K along with 1.5 kg B ha^{-1} recorded higher cost-benefit ratio (7.75 Rs) than other treatments. With respect to response ratio also the same treatment combination registered higher value than other treatments and it is optimum for obtaining highest maize yield.

From the field investigation, it can be concluded that in Inceptisol, soil application of boron @ 1.5 kg B ha^{-1} with 100 per cent N, P and K can be recommended for higher maize grain and straw yield. Foliar application of B also significantly increased the grain and straw yield of maize. The sufficiency in yield was also achieved with 0.2% concentration itself. With regard to sources, Agribor was found to be better when compared to borax and boric acid in influencing the yield of maize crop.

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