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Influence of Sources and Levels of Boron on its Availability Tomato Yield and Fertility Status of Post-harvest Soil

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ABSTRACT

The experimental soil was collected from Meethikudi village representing medium textured soil of Cuddalore district. The incubation experiment was conducted at Annamalai University to study the effect of boron fertilizers on its availability in soil. The four sources and three levels of boron were evaluated at 90 DAI. Addition of 1.5 mg B kg^{-1} through calcium boro humate with RDF recorded the highest value of water-soluble boron (1.7 mg kg^{-1}) on 90 DAI and minimum under 0.5 mg B kg^{-1}. The pot experiments were conducted to evaluate the response of tomato to sources of boron. Same set of treatments were followed as per incubation experiment. The higher fruit (1881 g pot^{-1}) and stover (362 g pot^{-1}) yield was received in treatment receiving B through calcium boro humate @ 1.5 mg kg^{-1} along with RDF. Post-harvest NPK status has not significantly affected by the treatments. Application of boron through polybor @ 1.5 mg kg^{-1} with RDF showed decreased available N (135.8 mg kg^{-1}), available P (12.1 mg kg^{-1}) and available K (68.4 mg kg^{-1}). Application of 1.5 mg B kg^{-1} through calcium boro humate with RDF recorded the highest post-harvest available B status of 1.6 mg kg^{-1}.

Key words**:** Tomato, Sources, Levels, Boron, Incubation, Fruit yield

Tomato (*Lycopersicon esculentum*) assumes great significance due to its nutritional excellence. It is one of the most popular and widely grown vegetable and cultivated throughout the world for its fresh and as well as for processed products. Apart from major plant nutrients boron plays an important role in the production of tomato. It is important for carbohydrate metabolism, translocation and development of cell wall and RNA metabolism. Boron plays an important role directly and indirectly in improving the yield of tomato. The increase in vegetative growth of tomato could be attribute to physiological role of boron and its involvement in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, resynthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages. Boron also has effect on many functions of the plant such as hormonal movement, active salt absorption, carbohydrates and nitrogen metabolism in the plants [1]. Considering the above facts, the present study was undertaken to study the transformation and release pattern of boron in soil applied with calcium borohumate (CBH) in incubation study and response of tomato sources and levels of boron.

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MATERIALS AND METHODS

The study involved an incubation experiment and a pot experiment conducted during 3rd September to 31st December 2019 at the Department of Soil Science and Agricultural Chemistry, Annamalai University with tomato as a test crop. The soil samples were collected from Meethikudi village (*Typic Haplustalf*) of Cuddalore district, Tamil Nadu to conduct incubation and pot experiments. The incubation experiments were conducted at Department of Soil Science and Agricultural Chemistry, Annamalai University using various sources of boron such as calcium borohumate (9% B), boric acid (17% B), borax (15% B), polybor (disodium octaborate tetrahydrate) (14% B) and 3 levels of B (0.5, 1.0 and 1.5 mg kg^{-1}). 200 g of 2 mm sieved soil sample was filled in 250 ml plastic containers. Each treatment was replicated thrice. The design followed was factorial completely randomized design (FCRD). The samples were drawn at 90 DAI and analyzed for available B content. Recommended dose of NPK fertilizer were 150:100:50 kg N, P_2O_5 and K_2O ha^{-1} was adopted. Pot experiments were conducted at pot culture yard in the Department of Soil Science and Agricultural Chemistry, Annamalai University, using medium textured soil collected from Meethikudi village. 20 kg weight of soil taken in pots transplanting of tomato seedlings were done in the pots. Four sources (calcium boro humate, boric acid, borax, polybor) and three levels (0.5, 1, 1.5 mg kg^{-1}) of boron were evaluated in factorial completely randomized design with three replications. The fruit and stover yield of the crop were recorded at harvest. Soil samples collected just before the start of the experiment and at harvest were analyzed for the available nutrient viz., NPK and B. The soil pH and electrical conductivity (EC) were determined in 1:2.5 soil: water suspension as described by [2]. Soil texture was determined by Bouyoucos hydrometer [3]. Organic carbon (0.2 mm sieved) was determined by wet oxidation method of [4]. For available N was determined by alkaline permanganate [5]. For available P, soil sample was extracted with 0.5 M $NaHCO_3$ (pH 8.5, [6] and P content in the extract was determined by ascorbic acid method [7]. Available K was determined by extracting soil with 1N NH_4OAC followed by measuring the K content using a flame photometer. The cation exchange capacity (CEC) was determined by the method given by [8] and hot water extractable B [9]. The data obtained in the present investigation were statistically analyzed by following the Indo Software. The soil samples used in the incubation and pot experiment were collected at Meethikudi village at Cuddalore district (Table 1). The soil was neutral in reaction, low in organic carbon content and available N, medium in available P and high in available K. The experimental soil was deficient in boron. The soil of experimental site belongs to Kalathur series and taxonomically comes under the order *Alfisol*, sub order *Ustalf*, great group *Haplustalf*, sub group *Typic Haplustalf*.

Table 1 Initial properties of soils of experimental site

Soil properties	Value
Soil Texture	Loam
Organic carbon (g kg^{-1})	7.3
pH (1:2.5)	7.1
Electrical conductivity (1:2.5) (dSm^{-1})	0.19
Cation exchange capacity [c mol(p^+) kg^{-1}]	18.5
Available potassium permanganate (kg ha^{-1})	282.8
Olsen-P (kg ha^{-1})	28.2
Ammonium acetate extractable K (kg ha^{-1})	146
Available hot water Extractable B content (mg kg^{-1})	0.49

RESULTS AND DISCUSSION

Incubation experiment

The data regarding the availability of boron as affected by different sources of boron under incubation period are reported in (Table 2). The result revealed that the different sources of boron produced significant decreased effect on availability of boron. The treatment received boron @ 1.5 mg kg^{-1} through calcium boro humate with RDF registered maximum B status of 1.7 mg kg^{-1} on 90 DAI. Among the different sources the rate of release of available boron was highest in calcium boro humate than boric acid, borax and polybor. In the experimental soil, the trend of hot water-soluble boron content transformed into some non-exchangeable forms. The adsorption of boron on clay minerals and fixation and exchange probably reduced these available contents in soil. This may be attributed for fixation and/or complexation of boron with organic and inorganic components of the soil [10].

Table 2 Effect of different boron fertilizers on the water-soluble boron on 90 DAI (mg kg^{-1})

Source of B	Boron level (L) (mg kg^{-1})			
	0.5	1.0	1.5	Mean
B_1 Calcium boro humate	0.75	1.18	1.70	1.24
B_2 Boric acid	0.70	1.20	1.60	1.16
B_3 Borax	0.70	1.20	1.60	1.16
B_4 Polybor	0.72	1.26	1.60	1.16
Mean	0.72	1.24	1.63	1.19
CD (P=0.05)				
Level (L)	0.09			
Source (S)	0.10			
L×S	0.18			

Fruit yield

Boron fertilization to tomato showed a significant improvement in fruit yield. Application of increasing levels of B up to 1.5 mg kg^{-1} consistently increased the fruit yield and at ranged from 920 to 1600 g pot^{-1} (Table 3). Application of B through form different sources showed a positive response in terms of fruit yield. Calcium Boro Humate and Polybor showed better performance than Boric acid and Borax. Interaction effect due to levels and sources significantly increased the fruit yield of tomato. Application of boron through calcium boro humate @ 1.5 mg kg^{-1} with RDF recorded the highest fruit yield of 1881 g pot^{-1}. Among the four sources tested calcium boro humate excelled the other sources viz., borax, boric acid and polybor. Based on the efficiency of different sources of boron in improving the tomato yield, the sources were arranged in descending order as calcium boro humate > polybor > Boric acid > Borax. This might be due to the better availability of boron throughout the period of crop growth in the boro humate applied plots as well as the influence on the dissociated humate ion on the availability and translocation of both micro and macro nutrients in the plants [11].

Stover yield

Application of graded levels of B from 0 to 1.5 mg kg^{-1} increased the stover yield from 266 to 350 g pot^{-1} (Table 3). Almost all the sources of B had significant increase in stover yield of tomato. Among sources, calcium boro humate maintained higher stover yield compared to other three. Application of 1.5 mg B kg^{-1} through calcium boro humate with RDF recorded highest stover yield of 360 g pot^{-1}. The increment in the study attributes by application is due to the fact that calcium is an essential constituent of plant cell wall and plays a significant function is cell division and enlargement. Ca directly involved in improving photosynthesis which results in high shoot growth [12]. Plant demand for boron as micronutrient varies broadly. Boron is linked with the development of plant cell wall and differentiation of cells and results in improved shoot growth. Soil humic acid application can result in an increase and improvement in stover yield [13].

Table 3 Effect boron fertilizers on the fruit yield and stover yield (g pot^{-1}) of tomato in *Typic Haplustalf*

Source of boron (B)	Fruit yield				Stover yield			
	Levels of boron (L) (mg kg^{-1})				Levels of boron (L) (mg kg^{-1})			
	0.5	1.0	1.5	Mean	0.5	1.0	1.5	Mean
B_1 Calcium boro humate	1324	1869	1881	1691	342	348	362	350
B_2 Boric acid	858	1364	1410	1210	272	321	314	302
B_3 Borax	794	1238	1361	1131	284	300	318	300
B_4 Polybor	1041	1683	1695	1473	326	334	342	334
Mean	1004	1229	1586	1376	306	325	334	321
CD (P=0.05)								
Level (L)		20.4				51		
Source (S)		23.4				58.5		
L×S		42				105		

Soil fertility

Available nitrogen

The result (Table 4) indicated that application of boron sources showed a slight decrease in availability of N but significant reduction was not noticed. Application of graded levels of boron gradually decreased nitrogen availability. The highest decrease in nitrogen availability (135.8 mg kg^{-1}) was noticed in treatment receiving polybor @ 1.5 mg kg^{-1}. The available nitrogen in soil was higher at flowering stage of crop and declined at post-harvest available nitrogen at later stage. This might be due to the uptake of nitrogen by the growing plants as described by [14].

Table 4 Effect of source and levels of boron on status of available NPK and water-soluble B in post-harvest soil (mg kg^{-1})

Treatments	N	P	K	B
Control	141.6	13.8	74.0	0.4
Calcium boro humate @ 0.5 mg kg^{-1}	138.5	13.6	70.6	0.7
Calcium boro humate @ 1.0 mg kg^{-1}	136.2	12.9	69.3	1.4
Calcium boro humate @ 1.5 mg kg^{-1}	135.9	12.2	68.6	1.6
Boric acid @ 0.5 mg kg^{-1}	140.1	14.0	73.2	0.6
Boric acid @ 1.0 mg kg^{-1}	139.8	13.4	71.9	1.2
Boric acid @ 1.5 mg kg^{-1}	137.4	12.7	69.8	1.4
Boron @ 0.5 mg kg^{-1}	141.2	14.2	73.8	0.6
Boron @ 1.0 mg kg^{-1}	140.4	13.6	72.4	1.2
Boron @ 1.5 mg kg^{-1}	138.2	13.0	70.2	1.42
Polybor @ 0.5 mg kg^{-1}	138.1	13.7	70.8	0.62
Polybor @ 1.0 mg kg^{-1}	136.4	12.9	69.4	1.25
Polybor @ 1.5 mg kg^{-1}	135.8	12.1	68.4	1.46
CD (P=0.05)	NS	NS	NS	NS

Available phosphorus

Post-harvest phosphorus status (Table 4) of soil was also slightly decreased due to boron fertilization. Application of graded levels of boron from 0 to 1.5 mg kg^{-1} gradually decreased the P availability. The highest decrease (12.1 mg kg^{-1}) was noticed in the treatment received polybor @ 1.5 mg kg^{-1}, but this reduction was not statistically significant. The available P content was higher in initial stages of tomato crop but declined at later stages. This may be due to uptake of phosphorus by growing plants and/or due to refixation of solubilized phosphorus [15].

Available potassium

Available potassium status of post-harvest soil (Table 4) does not show any significant variation due to boron fertilization. As like N and P, the potassium status also showed slight decline. The maximum decrease (68.4 mg kg^{-1}) was noticed in the treatment received polybor @ 1.5 mg kg^{-1}. Neither the increasing levels of boron nor the sources of boron did not influence of the soil potassium status significantly. This might be due to higher uptake of nutrients by plants and its further translocation to various plant parts including fruit, besides being subjected to other losses [16]. Moreover, with interaction with boron and potassium show negative at low boron concentration of experimental soil (68.4 mg kg^{-1}) as reported by [17].

Available boron content in soil

Application of various sources of boron at different levels consistently increased water-soluble boron status in the soil. Application of graded levels of boron from 0 to 1.5 mg kg^{-1} consistently increased the available B status from 0.4 to 1.6 mg kg^{-1}. Application of 1.5 mg kg^{-1} through calcium boro humate recorded the highest available B status of 1.6 mg kg^{-1}. The results concluded that the application of humic acid with calcium and boron might upgrade the health of soil by modifying soil chemical characteristics and enhancing its nutrient status [18].

CONCLUSION

Considering the salient findings is perspectives the study concluded that application of 1.5 mg B kg^{-1} through calcium boro humate with RDF found to be best in water soluble boron in incubation study and pot culture, fruit and stover yield of tomato in pot experiment. Application of boron through polybor @ 1.5 mg kg^{-1} along with RDF registered lowest values of post-harvest available NPK.

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