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Research Article

Effect of Boron and Farmyard Manure on Different Types of Soil Boron Forms

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Abstract

An experiment was conducted at Agriculture University Chatha in order to evaluate the effect of Boron and FYM application on different types of soil Boron. Composite surface soil samples (0-15 cm) from different locations were collected and analyzed for water soluble boron (WSB), Hot water soluble boron (HWS-B), Calcium chloride soluble boron (CCSB) and Acid soluble boron (ASB) using standard procedures. It was found that T_7 (15 kg ha^{-1} borax along with 100% FYM) was highly effective among all thereby reflecting 31.5% higherwater soluble boron availability than control and 54.2% increase in Acid soluble boron. In addition to this, higher values of Hot water soluble boron and Calcium chloride soluble boron were noticed in the same treatment. Therefore, in future farmers can be advised to use the Borax @ 15 kg ha^{-1} along with 100% of FYM as a promising treatment to increase boron availability compared to others.

Keywords: *Water soluble boron, Hot water soluble boron, Calcium chloride soluble boron and Acid soluble boron.*

Abbreviations: B- Boron, WSB- Water soluble boron, HWS-B- Hot water soluble boron, CCSB- Calcium chloride soluble boron, ASB- Acid soluble boron.

Introduction

Boron is unique among the essential mineral elements because is normally present in soil solution as a non-ionized molecule in the pH range which is suitable for plant growth (Goldberg, 1993). Boron is neither an enzyme constituent nor does it directly affect enzyme activities of plants. It is an important micronutrient for plant growth and for K^+ transport into guard cells thereby controlling stomata opening. It also plays vital role in germination, pollen tube growth, cell division, protein synthesis, translocation of sugars and cell wall synthesis. In experiments conducted throughout the country; optimum yields were obtained when crops were supplied with adequate amount of this nutrient (Ross, *et al.*, 2006; Zou, 1991) and its application to the soil increased head yield of broccoli (Yang, X. *et al.*, 2000).Boron is directly involved in severalphysiological and bio-chemical processes during plant growth (Yamagishi andYamamoto, 1994) and (Shelp, 1993). Dubey (1996) major role of Boron in plants is also to maintain the membrane integrity and cell walldevelopment, which affects permeability, cell-division and its extension.

Application of B or FYM individually increased the plant height, capitalism diameter, dry matter yields of seed and stalk and their B concentration and accumulation. The interaction of B and FYM levels had a significant influence on B concentration of stalk and total B in soils (Kaur and Nelson, 2015).

The aim of the current experiment is therefore focused on:

To evaluate the impact of Boron on water soluble boron (WSB), Hot water soluble boron (HWS-B), Calcium chloride soluble boron (CCSB) and Acid soluble boron (ASB) in soils.

To evaluate the impact of FYM on water soluble boron (WSB), Hot water soluble boron

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(HWS-B), Calcium chloride soluble boron (CCSB) and Acid soluble boron (ASB) in soils.

Material and Method

Composite surface soil samples (0-15 cm) from different locations were collected. The soil samples were brought in the laboratory and allowed to dry at room temperature. On drying big clods were broken and the soil was grinded with wooden pestle and mortar leaving no aggregates and the soil was finally passed through 2mm sieve. After sieving, the soil samples were kept in polythene bags separately for analysis. The samples were cleaned, dried and analysed for investigations.

Four forms of B were determined which are water soluble boron, hot water soluble boron, calcium chloride soluble boron and acid soluble boron which are as follows:

Water Soluble Boron

Water soluble boron (WSB) was extracted by shaking 20 g of soil with 20 ml distilled water in a 50 ml polyethylene centrifuge tube for 2 hours (Hatcher and Wilcox, 1950). The contents were centrifuged and were filtered using Whatmann No. 42 filter paper. The filtrate was preserved in refrigerator for B estimation.

Hot Water Soluble Boron

Hot water soluble boron (HWS-B) was extracted by refluxing the soil with boiling distilled water (1:2) for five minutes as described by Wear (1965). The content was filtered using Whatman No. 42 filter paper. The filtrate was preserved in refrigerator for boron estimation. Spectrophotometer that can measure absorbance at a wave length of 420 nm.

Calcium Chloride Soluble Boron

Calcium chloride soluble boron (CCSB) was extracted as per the method proposed by Wear (1965). For determination of CCSB, 10 g of soil, 20 ml of 0.01M $CaCl_2$ and pinch of activated charcoal was added in a 250 ml Erlenmeyer flask. Reflux condenser was attached to the flask. The mixture was heated on a hot plate for 5 minutes and refluxed thereafter for 5 minutes. The content of the flask were filtered through Whatman No. 42 filter paper and was preserved for B estimation.

Acid Soluble Boron

Acid soluble boron (ASB) was extracted by shaking 10 g soil with 20 ml of 0.05 N HCl is 50 ml polyethylene centrifuge tube for 5 minutes followed by centrifuging and the supernatant was preserved for B estimation (Cayton and Poonamperuma, 1981).

Design, Plot Size and Layout of the Experiments

Crop – Broccoli (*Brassica oleracia L var. italica*)
Variety – PalamSamridhi
Design – Randomized Block Design (RBD
Replications – 3 (R_1, R_2 and R_3)
Treatments – 10 (Details are given in table 4)
Plot size – 3 m × 3 m = 9 m²
Spacing – 60 cm × 45 cm
Total Number of plants/plot – 30
Total number of Plots/replication – 10

Treatment Details

S No.	Notation	Treatments
1.	T_1	Control (Recommended dose of NPK)
2.	T_2	Spray of Boron @ 0.3% 20 days after transplanting + recommended dose of NPK and 100% of FYM
3.	T_3	Spray of Boron @ 0.3% 35 days after transplanting + recommended dose of NPK and 100% of FYM
4.	T_4	Spray of Boron @ 0.3% 45 days after transplanting + recommended dose of NPK and 100% of FYM
5.	T_5	Soil application of borax @ 10 kg ha^{-1} + recommended dose of NPK and 100% of FYM

6.	T_6	Soil application of borax @ 12.5 kg ha^{-1} + recommended dose of NPK and 100% of FYM
7.	T_7	Soil application of borax @ 15 kg ha^{-1} + recommended dose of NPK and 100% of FYM
8.	T_8	Soil application of borax @ 10 kg ha^{-1} + recommended dose of NPK and 50% of FYM
9.	T_9	Soil application of borax @ 12.5 kg ha^{-1} + recommended dose of NPK and 50% of FYM
10.	T_{10}	Soil application of borax @ 15 kg ha^{-1} + recommended dose of NPK and 50% of FYM

Results and Discussion

Water Soluble Boron (WSB) Content

The data presented in Table 1 showed that foliar as well as soil application of B at different levels significantly increased water soluble fraction of B in soil over control during both the years of experimentation.

Water soluble boron is the low fraction of available B in soil. The current investigation demonstrated that WSB of the soil of experimental area ranged between 0.27 to 0.36 mg kg^{-1}. However, it ranged between 0.26 to 0.30 mg kg^{-1} in surface soils of vegetable growing area of Jammu district. The WSB content of Egyptian soils ranged from 0.1 to 2.6 ug ml^{-1} with a mean value of 0.6 ug ml^{-1} (Elseewi and Elmalky, 1979). The content of WSB varied from 0.43 to 1.29 ppm with an average of 0.73 ppm in non-saline soils and 0.43 to 2.58 ppm with an average of 0.73 ppm is low saline soils of Delhi (Gajbhiye, *et al*., 1980).

In semi-arid soils of Punjab WSB content ranged from 0.12 to 0.56 mg kg^{-1} with mean value of 0.27 mg kg^{-1} (Arora and Chahal, 2007). Results conducted for two years depicted that T_7 (soil application of borax @ 15 kg ha^{-1} + recommended dose of NPK + 100% of FYM) recorded highest content of WSB fraction (0.363 mg kg^{-1}) in the soil followed by treatment T_6 (0.357 mg kg^{-1}).

However, WSB content recorded under T_7 (15 kg ha^{-1} borax along with 100% FYM) was 31.5% higher than that under control. The high mean content of WSB in treatment T_7 might be because of higher organic matter content added through the FYM where B was closely associated. Such positive effects of FYM on B availability in soil were associated with increased OC content, and ascribed to greater chelating of B by organic matter mainly due to formation of B-diol complexes with the breakdown products of soil organic matter (Yermiyahu, *et al*., 2001). Furthermore, higher decomposition rate of organic matter in sub-tropical climate produces different organic acids *viz*., tartaric, oxalic, citric, acetic, formic, fulvic and humic acids, which solubilized relatively unavailable, fixed or adsorbed B in clay, thus increasing B availability (Niaz*et, al*., 2007).

Table 1: Effect of B and FYM application on water soluble boron content in soil at harvest

Notation	Treatments	Water soluble boron (mg kg^{-1})		
		1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	0.274	0.277	0.276
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	0.321	0.324	0.323
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	0.321	0.325	0.323
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK +	0.322	0.325	0.324

	100% of FYM			
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	0.350	0.354	0.352
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	0.356	0.358	0.357
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	0.360	0.365	0.363
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	0.338	0.344	0.341
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	0.342	0.348	0.345
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	0.344	0.355	0.350
	F-Value	86.78	90.36	96.36
	CD (0.05)	0.008	0.008	0.008
	SE(m) ±	0.003	0.003	0.003
	CV	1.393	1.402	1.339

Hot Water Soluble Boron (HWSB) Content

As evident from Table 2, HWSB content in soil recorded significantly higher values in foliar as well as soil application of B over control during 1st and 2nd year of experimentation.

Hot water soluble boron is commonly used as index of B availability in soils. The current investigation demonstrated that HWSB of the soils of experimental area ranged from 0.33 to 0.53 mg kg^{-1} and in vegetable growing area of Jammu district it varied from 0.32 to 0.38 mg kg^{-1}. Earlier studies conducted by Mondal, (2002) indicated that HWSB ranged from 0.21 to 0.68 with mean value 0.36 mg kg^{-1} for twelve soils of Bhaderwah, (J&K). Kher and Isher, (2006) also reported a range of 0.12 to 0.34 mg kg^{-1} in respect of HWSB in citrus soils of Jammu region. The average content of HWSB ranged from 0.10 to 2.00 mg kg^{-1} soil on worldwide basis (Aubert and Pinta, 1977) whereas the range of available B in soils of different states of india varied from traces to 12.20mg kg^{-1} soil (Das, 2000).

Pooled data recorded maximum content of HWSB (0.53 mg kg^{-1}) in T_7 comprising soil application of borax @ 15 kg ha^{-1} along with 100% FYM which was significantly higher than all other treatments. The HWSB was found to be comparatively high in soils supplied with FYM and boron which might be due to comparative higher organic matter and B content of soil. This contention got support from the significant positive relationship of HWSB with OC and B content. Sharma and Bajwa (1989) observed positive and significant correlation between HWSB and organic matter, while Singh and Randhawa (1977) found significantly negative relationship between HWSB and organic matter content of the soils. Positive significant correlation was noted between HWSB and CEC by Borkakti and Takkar (2000) in Assam soils.

Table 2: Effect of B and FYM application on hot water soluble boron content in soil at harvest

Notation	Treatments	Hot Water Soluble Boron (mg kg^{-1})		
		1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	0.329	0.332	0.331
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	0.395	0.400	0.398

T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	0.399	0.407	0.403
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	0.400	0.415	0.408
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	0.521	0.530	0.525
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	0.527	0.534	0.530
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	0.532	0.545	0.539
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	0.500	0.511	0.506
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	0.506	0.517	0.512
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	0.513	0.526	0.519
	F-Value	143.74	159.59	156.96
	CD (0.05)	0.018	0.018	0.018
	SE(m) ±	0.006	0.006	0.006
	CV	2.291	2.194	2.200

Calcium Chloride Soluble Boron (CCSB) Content

The data presented in Table 3, showed that all the treatment comprising soil application of borax along with 100% FYM as well as 50 % FYM and foliar application @ 0.3 % of B applied at different time intervals recorded significant over control during both the years of experimentation. No significant difference in CCSB content in soil was observed among all the treatments of foliar application of B @ 0.3% boron applied at different time intervals along with 100% FYM during both the years.

Earlier studies conducted by Sharma, (2005) had indicated that CCSB ranged from 0.02 to 1.21 mg kg^{-1} for apple orchard soils of Bhaderwah, (J&K). Chaudhary and Shukla, (2004) reported that arid soils of western Rajasthan contained 0.24 to 1.79 mg kg^{-1} of CCSB. A range of 0.13 to 1.51 mg kg^{-1}CCSB was also reported by Shah, *et al.* (1998) in swell shrink soils of Madhya Pradesh. The results indicated that hot $CaCl_2$ was capable of extracting B from three important B fractions (Datta, *et al.,* 2002; Sarkar, *et al.,* 2008). As the experimental site non-calcareous and contains minimal amount of oxides and pH also non-acidic, organically bound B fraction mainly governs the availability of native B in soil, as far as plant uptake is concerned. High correlation between CCSB and organically bound B suggests that this fraction of B serves as buffering stock or quantity factor of B supplying power of soils as reported elsewhere (Jin, *et al*., 1987).

Table 3: Effect of B and FYM application on calcium chloride soluble boron in soil at harvest

Notation	Treatments	Calcium chloride soluble boron (mg kg^{-1})		
		1st Year	**2nd Year**	**Pooled**
T_1	Control (Recommended dose of NPK)	0.362	0.366	0.364
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	0.441	0.450	0.445
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100%	0.443	0.451	0.447

	of FYM			
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	0.445	0.452	0.448
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	0.559	0.565	0.562
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	0.567	0.575	0.571
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	0.572	0.580	0.576
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	0.527	0.537	0.532
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	0.535	0.544	0.540
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	0.542	0.550	0.546
	F-Value	319.17	503.56	550.95
	CD (0.05)	0.012	0.010	0.009
	SE(m) ±	0.004	0.003	0.003
	CV	1.386	1.098	1.052

Acid Soluble Boron (ASB) Content

The result in Table 4 indicated that different levels and methods of B application.

Acid soluble boron is the dominant fraction of the available forms of boron. The investigations demonstrated that ASB of the soils of experimental area had values ranging from 0.38 to 0.59 mg kg^{-1} and in vegetable growing area of Jammu district it varied from 0.39 to 0.42 mg kg^{-1}. In the profiles study of Junagadh and Rajkot district of Gujarat, the ASB content ranged from 1.2 to 3.9 and 1.0 to 3.8 ppm (Hadwani, *et al*., 1989). Acid soluble boron content in salt affected soils of Punjab ranged from 0.1 to 25.3 ppm, which was higher than WSB and HWSB content (Sharma and Bajwa, 1989). In the studies conducted, the ASB content was higher than the WSB, HWSB and CCSB which could be attributed to dissolution of some insoluble salts and complexes of B under sub-tropical environment. The highest amounts of soil B originated from residual form generally ranged from 70 to 99% of total soil B (Hadwani, *et al*., 1989). This form of B accounted for major contribution to total B among all other B fractions (Karthikeyan and Shukla, 2011).

Table 4: Effect of B and FYM application on acid soluble boron in soil at harvest

Notation	Treatments	Acid soluble boron (mg kg^{-1})		
		1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	0.382	0.389	0.385
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	0.451	0.457	0.454
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	0.450	0.458	0.454
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	0.451	0.458	0.455
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	0.580	0.585	0.582

T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	0.586	0.592	0.589
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	0.591	0.597	0.594
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	0.544	0.545	0.545
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	0.552	0.554	0.553
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	0.555	0.562	0.559
	F-Value	701.34	570.95	749.44
	CD (0.05)	0.008	0.009	0.008
	SE(m) ±	0.003	0.003	0.003
	CV	0.937	1.016	0.897

Conclusion

In conclusion, WSB content recorded under T_7 (15 kg ha^{-1} borax along with 100% FYM) was 31.5% higher than that under control.HWSBmaximum content in soil (0.532 mg kg^{-1} during 1st year and 0.545 mg kg^{-1} during 2nd year) were recorded under the soil application of borax @ 15 kg/ha along with 100% FYM (T_7) which was significantly higher as compared to all other treatments. Soil application of borax @ 15 kg ha^{-1} along with 100% FYM registered highest content of CCSB in soil (0.57 mg kg^{-1} in 1st year and 0.58 mg kg^{-1} in 2nd year) which was significantly higher as compared to borax @ 10 kg ha^{-1} along with 100% FYM. In case of ASB, T_7 (Soil application of Borax @ 15 kg ha^{-1}along with 100% of FYM) caused 54.2% increase in ASB content in soil over control. Thus, in future farmers can be advised to use the application of Borax @ 15 kg ha^{-1} along with 100% of FYM as a promising treatment compared to others.

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