

Original Research Article

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To Investigate the Rate of Release of Boron from Different Sources and Levels of Boron at Varying Period of Incubation

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ABSTRACT

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The time of incubation had the pronounced effect on boron availability. The boron availability of each product increased up to 45th days of incubation period, and then it was decreased. Availability of boron seems to have direct relationship with the quantity of applied boron. Thus, the overall availability of boron increased with the increasing dose of applied boron sources. Among the different sources of boron, the rate of release of available boron was highest in Boric acid followed by Borax and Agricol. The interaction effect of different sources and periods was found significant. The highest availability of boron was registered at 45th days of incubation period with 10 ppm Boric acid treatment.

Introduction

Boron is one of the seven essential micronutrients required for normal growth and development of plant. The original source of B in most soils is tourmaline which contains 3-4% B. It is quite resistant to weathering hence the release of B from it is quite slow. Boron being the only element that is normally present in the soil solution as a non ionized molecule (H_3BO_3) over the pH range suitable for plant growth. It helps in increasing the permeability of cell membranes in the plants. It involves in sugar translocation, metabolism

of carbohydrates and auxin, flower fertility, cellular activities and chlorophyll synthesis. It also plays a vital role in protein synthesis and related to calcium, potassium metabolisms in plants (Tisdale *et al.*, 1985).

In recent years, the importance of micronutrients in increasing agricultural production and correcting deficiencies in plants has been greatly realized. In India, the deficiencies of micronutrients have been observed in the light texture and calcareous soils. The situation has been further aggravated with the introduction of high

yielding crop varieties, intensive cropping system, heavy fertilization with high purity grade fertilizers and decrease in the use of bulky organic manures and recycling of crop residues. The accompanied changes in the soil management practices also frequently alter the micronutrient availability. In order to maintain the level of productivity of the soils, it is desired to keep the complete account in their status and changes being taking place with regards to their substitute and production.

Materials and Methods

Incubation study

The details of experiment are given below.

1. **Design of experiment:** Completely Randomized Design with 63 treatment combinations.
2. **Treatment:** There were three sources of boron and seven levels of boron and six period intervals as follows.

(a) Three sources of boron

Symbol	Sources
S ₁	Agricol (Coleminite)
S ₂	Borax crystals
S ₃	Boric acid

(b) Seven levels of boron

Symbol	Levels
L ₀	0.0 mg kg ⁻¹
L ₁	1.0 mg kg ⁻¹
L ₂	2.0 mg kg ⁻¹
L ₃	4.0 mg kg ⁻¹
L ₄	6.0 mg kg ⁻¹
L ₅	8.0 mg kg ⁻¹
L ₆	10 mg kg ⁻¹
(c) Replication	: 3 (three)
(d) Location	: U. G. Laboratory, Department of Agril. Chemistry and Soil Science, College of Agriculture, J. A. U. Junagadh.
(e) Moisture maintained	: At field capacity

Incubation period

There were six different periods of incubation. The sampling done at the intervals as mentioned in Table A.

Method of incubation

One kg soil was taken in a plastic bowl and the soil was treated with seven levels of boron (0.0, 1.0, 2.0, 4.0, 6.0, 8.0, and 10 mgkg⁻¹) and

three source of boron (Agricol, Borax crystal and Boric acid) as per treatments in triplicate at room temperature (27°- 30° C) in the laboratory. The soil moisture content was maintained at field capacity of the soil and loss in water content in soil was made up throughout the incubation period by addition the water as determined by the loss in weight of bowl soils.

Periodical soil sampling at each interval (15th,

30th, 45th, 60th, 75th and 90th) was done with the help of a plastic tube. The soil sampling was done from 3 spots of each bowl considering entire depth of bowl. The soil was air dried, passed in 2 mm sieve and analyzed for hot water soluble (HWS) boron. The incubation study was started on 11th June, 2007 and completed 11th August, 2007.

Results and Discussion

Effect of different sources of boron and incubation periods on availability of boron

The data regarding the availability of boron as affected by different sources of boron and incubation periods are reported in table 1. The result revealed that the different sources of boron produced significant effect on availability of boron. The maximum availability of boron was registered with Boric acid (3.57 ppm), while lowest was observed with Agricol product (0.96 ppm). All the sources were significant with each other. Among the different sources, the rate of release of available boron was highest in Boric acid followed by Borax and Agricol treatments.

A close look at this table reveals that there was an apparent effect of time of incubation on the availability of boron (Table 1). The mean values of boron availability for different time intervals show that there was significant effect of time of incubation, which increased the availability of boron up to 45th days period. Then it was significantly decreased with all the sources. The maximum availability was observed at 45th days period (2.69 ppm) while beyond this period it was decreased up to 90th days. The lowest availability was observed at 90th days period (1.37 ppm). The interaction effect of different sources and periods was found significant. The highest (4.57 ppm) availability of boron was registered at 45th days with boric acid

treatment, while lowest (0.76 ppm) boron availability was found at 15th days with Agricol treatment. In the experimental soil, the trend of change in HWS-B content was found to record a significant and gradual decrease with the advancement of incubation period. Further, at later stages of incubation, greater amounts of HWS-B content transformed into some non-exchangeable forms as compared to early period of incubation. These results are in line with the findings by Gupta (1968), Khanh *et al.*, (2005) and Girish Chander *et al.*, (2007). The adsorption of boron on clay minerals and fixation and exchange (Keren and Bingham, 1994) probably reduced these available contents in soil. This may be attributed to fixation and/or complexation of B with organic and inorganic components of the soil (Evans and Sparks (1983).

Effect of different sources and levels of boron on availability of boron

The results of different sources and levels of boron on availability of boron are reported in table 2. The different sources of boron produced significant effect on rate of release of available boron. The maximum availability of boron was registered under Boric acid (3.57 ppm), while lowest was observed under Agricol (0.96 ppm).

The Agricol significantly increased availability of boron with increase in level of boron except 1 ppm level, where it was at par with 0 level of boron. The similar trend was also observed in case of Borax and Boric acid. The highest (3.98 ppm) availability was recorded at 10 ppm level of boron concentration. The lowest (0.54 ppm) availability was registered at 0 ppm of boron concentration.

The interaction effect of level and sources of boron on boron availability was found significant. The maximum availability of

boron (7.37 ppm) was observed in Boric acid at 10 ppm application of boron concentration, while minimum availability of boron (0.53 ppm) was observed in Agricol at 0 ppm level of concentration i.e. no application of boron.

It is clearly indicated that the availability of boron in each source significantly increased with increase in levels of boron. The application of boron obvious to increase the available boron content in soil, Prasad and Byrne (1975) reported that the boron concentration significantly improved boron status in soil. More or less similar results were also reported by Evans and Sparks (1983) and Girish Chander *et al.*, (2007).

Interaction effect of boron levels, sources and incubation periods on boron availability

The pooled data regarding the effect of boron levels, boron sources and incubation periods are presented in Table 3. The pooled results of interaction over entire period of incubation showed significant effect. It was found that at zero level of boron to 10 ppm boron application with different sources, the

availability of boron increased but the rate of increase was much higher when boron was applied @ 10 ppm. It is seen that although the interaction was significant, the trend of boron availability at different incubation period did not found consistent. The trend was almost similar when the combined effect of boron sources and boron level was examined at individual incubation periods.

The interaction of period-source-level was significant. It is the point to note that when levels of boron, source and incubation period increase simultaneously the rate of increase in availability of boron was more than at any constant level of factor. The combination of 10 ppm boron, 90th day incubation and boric acid source increased the availability of boron by four times compared to the combination of no application of boron at 15th days of incubation in Agricol. The availability of boron increased to a grater extent by combined application of period, level and source than varying in levels of any single factor. These results are in affirmation with those of earlier workers Keren and Bingham, (1994); Khanh *et al.*, (2005) and Girish Chander *et al.*, (2007).

Table.1 Effect of different sources of boron and incubation periods on availability of boron (ppm)

Treatments	Sources of boron (ppm)			Mean
	Agricol – S ₁	Borax – S ₂	Boric acid – S ₃	
15 th days	0.76	1.04	3.79	1.86
30 th days	0.88	1.41	4.19	2.16
45 th days	1.40	2.09	4.57	2.69
60 th days	1.09	1.87	3.71	2.22
75 th days	0.93	1.46	2.93	1.77
90 th days	0.68	1.18	2.24	1.37
Mean	0.96	1.51	3.57	
Treatment	S.Em+	C.D. at 5%	C.V. %	
S	0.016	0.046	10.39	
P	0.018	0.051		
S X P	0.041	0.124		

Table.A Incubation period

Sr.No	Particulars	Treatments
1.	Fifteen day after application of B	15 th
2.	Thirty day after application of B	30 th
3.	Forty five day after application of B	45 th
4.	Sixty day after application of B	60 th
5.	Seventy five day after application of B	75 th
6.	Ninety day after application of B	90th

Table.2 Effect of different sources and levels of boron on availability of boron (ppm)

Treatments	Sources of boron (ppm)			Mean
	Agricol – S ₁	Borax – S ₂	Boric acid – S ₃	
0 ppm	0.53	0.53	0.56	0.54
1 ppm	0.55	0.72	1.24	0.84
2 ppm	0.64	0.83	2.31	1.26
4 ppm	0.88	1.35	3.32	1.85
6 ppm	0.94	1.80	4.45	2.40
8 ppm	1.47	2.45	5.74	3.22
10 ppm	1.71	2.86	7.37	3.98
Mean	0.96	1.51	3.57	
Treatment	S.Em+	C.D. at 5%	C.V. %	
S	0.016	0.046	10.39	
L	0.020	0.055		
S X L	0.044	0.124		

Table.3 Interaction effect of boron levels, sources and incubation periods on boron availability

Incubation periods	Levels of boron	Sources of boron (ppm)		
		Agricol	Borax	Boric acid
15 day	0 ppm	0.38	0.44	0.46
	1 ppm	0.41	0.51	1.35
	2 ppm	0.52	0.62	2.25
	4 ppm	0.64	0.74	3.07
	6 ppm	0.73	0.85	4.60
	8 ppm	1.22	2.00	6.42
	10 ppm	1.43	2.13	8.38
30 day	0 ppm	0.54	0.57	0.61
	1 ppm	0.48	0.63	1.57
	2 ppm	0.66	0.79	2.51
	4 ppm	0.78	1.20	3.46
	6 ppm	0.75	1.90	5.43

	8 ppm	1.38	2.27	6.78
	10 ppm	1.57	2.48	8.96
45 day	0 ppm	0.67	0.61	0.67
	1 ppm	0.69	0.74	1.66
	2 ppm	0.82	1.20	2.81
	4 ppm	1.58	1.91	4.31
	6 ppm	1.58	2.54	5.64
	8 ppm	2.16	3.48	7.54
	10 ppm	2.34	4.13	9.35
60 day	0 ppm	0.56	0.55	0.59
	1 ppm	0.62	1.30	0.63
	2 ppm	0.70	0.98	2.49
	4 ppm	0.90	1.66	3.62
	6 ppm	1.07	2.27	4.40
	8 ppm	1.80	2.95	6.01
	10 ppm	2.01	3.34	8.20
75 day	0 ppm	0.54	0.53	0.56
	1 ppm	0.59	0.62	1.17
	2 ppm	0.62	0.77	2.19
	4 ppm	0.77	1.39	3.12
	6 ppm	0.86	1.90	3.69
	8 ppm	1.44	2.32	4.49
	10 ppm	1.69	2.70	5.27
90 day	0 ppm	0.48	0.48	0.46
	1 ppm	0.49	0.52	1.05
	2 ppm	0.52	0.62	1.63
	4 ppm	0.63	1.19	2.32
	6 ppm	0.64	1.34	2.95
	8 ppm	0.82	1.69	3.22
	10 ppm	1.90	2.38	4.06
Treatments		S.Em +	C.D. at 5 %	C.V. %
S X P X C		0.10	0.30	10.39

The summary and conclusion are as follows:

An incubation study was undertaken to know the effect of different sources (Boric acid, Borax and Agricol) and levels (0.0, 1.0, 2.0, 4.0, 6.0, 8.0 and 10.0 ppm) of boron at various incubation periods (15th, 30th, 45th, 60th, 75th, and 90th day) on boron availability. The time of incubation had the pronounced effect on boron availability. The boron availability of each source increased up to 45th

days of incubation period, and then it was decreased. Availability of boron seems to have direct relationship with the quantity of applied boron. Thus, the overall availability of boron increased with the increasing dose of applied boron sources. The different sources of boron produced significant effect on rate of release of available boron. Among the different sources of boron, the rate of release of available boron was highest in Boric acid followed by Borax and Agricol. The

interaction effect of different sources and periods was found significant. The highest availability of boron was registered at 45th days of incubation with 10 ppm Boric acid treatment.

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