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THE BORON CONTENT OF SOILS, PLANTS, AND FERTILIZER MATERIALS

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INTRODUCTION

Although there is a very narrow margin between the minute quantities that are necessary and the quantities that are toxic, boron is now recognized as an essential nutrient for normal plant growth.

In plant tissue, boron often is present in fairly large amounts compared with the amounts detectable in soils. With the exception of special cases, boron is not added to the soil as fertilizer, but it is known that various crops absorb it from the soil year after year.

Aware of these facts, and evaluating their importance relative to plant nutrition, it is highly essential that we know the distribution of boron in soils, fertilizers and plants.

In this report, the author presents some facts obtained from his experiments in analysing the distribution of boron in Japanese soils, plants and fertilizer materials.

EXPERIMENTAL METHODS

To determine the minute quantity of boron, various spectroscopic, titrating (both ordinary and electrometric) and colorimetric methods were introduced by many investigators in the past. After studying some of these methods, the author found that the Berger and Troug method was most suitable for his purpose; consequently this method has been employed in this study.

This is the one known as the colorimetric method which employs the reaction between Quinarizarin (1, 2, 5, 8, tetrahydroxyl anthraquinon) and boron in concentrated sulfuric acid. (on details, see original.) (1)

Results

Deta on the boron content in various Japanese soils are presented in table 1.

Table 1. Total and Available (Water soluble) Boron Content in various Soils. (p.p.m. in dry basis.)

Sample No.	Type and Depth.	Available boron.	Total boron.	* A/T×100.
(a) Virgin Soil.				
B. 2.	clayey loam.	0.11	23.15	0.48
5.	clay.	0.28	15.59	1.80
7.	clay.	0.22	11.63	1.89
13.	clayey loam.	0.14	18.17	0.77
C. 3.	sandy loam.	0.10	14.11	0.71
9.	loam.	0.28	2.80	10.00
11.	loam.	0.17	1.46	11.64
20.	clay.	0.21	10.26	2.04
30.	loam.	0.24	17.47	1.25
38.	clay.	0.26	28.77	0.90
D. 2.	sandy loam.	0.36	10.21	3.53
8.	sandy loam.	0.32	10.64	3.00
11.	sandy loam.	0.16	13.01	1.23
12.	loam.	0.21	2.94	7.14
E. 3.	loam.	0.29	3.92	7.10
5.	clayey loam.	0.29	24.26	1.02
8.	clay.	0.34	38.62	0.88
F. 1.	loam.	0.32	21.55	1.21
5.	sandy loam.	0.10	12.78	0.78
11.	clay.	0.16	10.70	1.50
13.	clay.	0.29	37.68	0.77
G. 2.	clay.	0.10	20.87	0.48
6.	clay.	0.38	39.38	0.96
14.	loam.	0.16	15.67	1.02

H.	1.	loam.	0.11	8.15	1.34
	9.	loam.	0.05	11.82	0.42
	12.	loam.	0.21	4.02	5.22
	13.	clayey loam.	0.33	16.72	1.97
	16.	loam.	0.10	11.52	0.86
K.	1.	clayey loam.	0.11	2.10	5.24
	2.	sandy loam.	0.21	3.91	5.37
	8.	clay.	0.32	11.45	2.72

(b) Arable Soil. (Samples are Fluvial Soil except W 1.–W 5.)

W.	1.	sandy loam.	0–20 cm.	1.52	13.16	11.55
			under 20	0.76	6.08	12.15
	2.	sandy loam.	0–20	0.40	26.29	1.52
			under 20	0.05	14.18	0.35
	3.	loam.	0–20	0.10	20.72	0.48
			under 20	0.10	22.60	0.44
	4.	loam.	0–20	0.32	27.31	1.15
			under 20	0.13	27.15	0.48
	5.	clayey loam.	0–20	0.41	16.29	2.52
			under 20	0.21	10.30	2.04
X.	1.	loam.	0–20	0.51	20.34	2.51
			under 20	0.20	30.55	0.66
	2.	sandy loam.	0–20	0.21	18.36	1.09
			under 20	0.20	28.07	0.73
	3.	sandy loam.	0–20	0.41	31.09	1.32
			under 20	0.20	39.92	0.50
	4.	loam.	0–20	0.33	30.48	1.08
			under 20	0.20	36.49	0.66
	5.	sandy loam.	0–20	0.20	5.37	3.72
			under 20	0.10	10.28	0.97
	6.	sandy loam	0–20	0.47	14.38	3.27
			under 20	0.13	6.15	2.11
	7	sandy loam.	0–20	0.20	30.69	0.65
			under 20	0.20	24.40	0.82
	8.	sandy loam.	0–20	0.20	20.39	0.98
			under 20	0.20	22.34	0.90
	9	loam.	0–20	0.33	5.79	5.70
			under 20	0.10	8.14	1.23

	10.	clayey loam.	0–20	0.30	16.15	1.86
			under 20	0.10	6.07	1.65
	11.	clayey loam.	0–20	0.25	8.07	3.10
			under 20	0.10	12.10	0.83
	12.	loam.	0–20	0.10	12.30	0.81
			under 20	0.10	16.35	0.66
	13.	clayey loam.	0–20	1.01	10.14	9.96
			under 20	0.20	8.92	2.24
	14.	loam.	0–30	0.30	12.10	2.48
			under 20	0.30	10.15	2.96
	(c) Marine Soil.					
R.	1.	clay.	0–13 cm.	2.99	20.61	14.51
			13–25	2.58	23.17	11.14
			25–56	3.61	23.17	15.18
			56–95	3.35	24.50	13.87
	2.	clay.	0–17	2.91	29.88	9.74
			17–30	6.90	28.52	24.19
			30–50	5.21	31.20	16.70
			50–70	7.85	28.72	27.33
	3.	clay.	0–15	2.76	24.27	11.37
			15–24	4.63	23.07	20.07
			24–56	7.39	21.79	23.50
			56–90	6.39	21.69	28.31
	4.	clay.	0–21	1.10	31.73	3.49
			21–38	1.43	31.70	4.51
			38–153	6.80	34.46	5.52
	5.	clay.	0–22	1.45	32.14	4.51
			22–63	2.59	34.00	7.62
			63–83	3.63	32.17	11.28
	6.	clay.	0–10	6.54	29.77	21.97
			10–20	5.47	32.33	16.19
			20–30	5.22	32.37	16.92
			30–50	4.71	29.89	15.76
K.	1.	clay.	0–20	3.66	43.81	8.35
			under 20	9.16	59.49	15.40
	2.	clay.	0–20	4.95	45.64	10.84
			under 20	9.87	45.76	21.63
	3.	clay.	0–20	9.44	25.51	37.01
			under 20	13.10	30.73	42.83

(d) Forest Soil.

M.	1.	loam.	A_0 horizon.	—	34.56	—
			A	0.75	42.86	1.75
			B	0.38	48.55	0.74
	2.		A_0	—	54.49	—
			A_1	1.75	47.85	4.08
			A_2	0.67	37.60	1.91
			B_0	0.40	28.84	1.53
			B_2	0.15	28.26	0.57
	3.	loam.	A_0	—	30.66	—
			A	0.50	36.63	1.47
			B_1	0.25	36.41	0.82
			B_2	0.10	46.74	0.24
			C	0.05	48.63	0.10
	4.	sand.	A_1	0.47	16.11	3.24
			A_2	0.75	14.10	1.21
			B_1	0.08	12.58	0.62
			B_2	0.06	17.75	0.34
			C	0.04	22.95	0.17

* A: available boron. T: total boron.

Table 2 indicates the boron content found in various representative fertilizer materials.

Table 2. Boron Content in Fertilizer Materials.
(p.p.m. in dry basis.)

Sample.	Boron Content.	Sample.		Boron Content.
Sulfate of potash.	26.4	Straw ash.	(a)	15.16
Muriate of potash. (Trona)	466.4		(b)	20.83
			(c)	21.18
Muriate of potash. (Palestein)	30.8		(d)	16.40
			(e)	21.13
Nitrate of soda. (Old style)	446.6	Grass ash.	(a)	102.46
			(b)	319.92
Nitrate of soda. (Champion)	83.6		(c)	160.66
			(d)	39.55

Rock phosphate.	(a)	26.4		(e)	52.07
	(b)	22.0	Wood ash.	(a)	261.13
	(c)	26.0		(b)	179.32
	(d)	20.0		(c)	169.22
Superphosphate	(a)	22.0		(d)	176.72
	(b)	22.0		(e)	126.79
Sulfate of ammonia.		0.0	Camphor-tree ash.	(a)	84.88
Cyanamid.		0.0		(b)	352.28
Guano (Peru)		0.0		(c)	172.18
Rape seed cake.		13.0		(d)	130.38
Soybean cake.		18.0		(e)	132.23
Kapok seed cake.		13.0	Rice-hull ash.	(a)	16.94
Cotton seed cake.		26.0		(b)	25.74
Pressed fish. (sardine)		0.0		(c)	20.30
Compost.	(a)	7.65		(d)	4.20
	(b)	3.44		(e)	15.23
	(c)	4.82	Suger cane ash.		40.73
	(d)	3.14	Corn stalk ash.		40.75
	(e)	13.22	Fern ash.		102.23
	(f)	6.05	Tobacco ash.	(a)	30.57
	(g)	4.25		(b)	101.00
	(h)	4.40		(c)	106.77
	(i)	5.48		(d)	114.52
				(e)	51.67
			Sweet poteto runner ash.		203.96

Table 3 indicates the boron content found in various plants, vegetables, and miscellaneous samples of plant orgigin.

Table 3. Boron Content in various Plants, Vegetables, and Miscellaneous samples. (p.p.m. in dry basis.)

Sample.		Boron Content.	Sample.	Boron Content.
(a) Leaves of trees.			(e) Cereals.	
Cryptomeria japonica.	(a)*	20.87	Rice (glutinous)	
	(b)*	14.88	unhulled rice.	0.64
Pinus Thumbergii.	(a)*	29.10	rice-hulls.	1.55

Picea jezoensis.	(a)*	49.63
Abies Mayriana.	(a)*	58.50
Fagus japonica.	(a)*	57.59
	(b)*	19.96
Cycas revolta.	(a)*	53.16

(b) Marine weeds.

Entesonorpha Luiza.		88.62
Ulva pertusa.		135.55
Porphyra tenera.	(1)	5.60
	(2)	3.28
	(3)	3.00
Gloiopeltis furcata.		51.52
Narnaluon puloinatum.		27.76
Gracilaria confervoides.		174.16
Hisikia fusifarme.		113.94
Nematocystus decipies.		63.52

(c) Fresh water weeds

Nostoc verrucosum.		12.84
Phylloderma sacrum.		trace.
Prasiola japonica.		2.25

(a) Vegetables.

Radish.	tops.	36.70
	roots.	20.90
Turnip.	tops.	44.04
	roots.	29.80
Japanese radish.	tops.	31.75
	roots.	14.69
Carrot.	tops.	33.80
	roots.	16.88
Lotus roots.		10.49
Welsh onion.		15.70
Spinach.		37.97
Chinese cabbage.		18.48
	straw.	1.41
Rice (non-glutinous)		
	unhulled rice.	0.50
	rice-hulls.	1.55
	straw.	0.88
Barley.	grain.	1.87
	straw.	1.77
Wheat.	grain.	2.11
	straw.	3.41

(f) Micellaneous amples.

Tobacco. (burley)		
	leaves.	48.12
	stalks.	11.74
	flowers.	28.25
Apples.	(1) leaves.	26.10
	fruit.	9.99
	(2) leaves.	51.66
	fruit.	11.83
	(3) leaves.	18.15
	fruit.	3.78
	(4) leaves.	56.34
	fruit.	25.30
	(5) leaves.	38.10
	fruit.	17.40

(a)* : fresh leaves. (b)* : fallen leaves.

Summary and Conclusion.

Robinson and his co-workers (2) reported that in forty-two samples of American soils, the total boron content ranged from 6.4 to 65.2 p.p.m. in dry basis and soluble boron (in phosphoric acid) from 1.0 to 45.5 p.p.m. in ninety-one samples.

Suijakova (3) found that in fifteen samples of U.S.S.R. soils, the total boron content ranged from 2.0 to 16.0 p.p.m. and water soluble boron from 0.19 to 1.10 p.p.m.

Amounts detectable in Japanese soils as observed by the author are in table 1. Viewing these results, it is evident that soils vary widely in their content of boron.

A brief summary of these studies is as follows.

	Samples examined.	Total Boron	Available Boron.
Virgin soil.	32	1.46—39.38	0.05— 0.38
Arable soil.	38	5.37—39.92	0.05— 1.52
Fluvial soil.	28	5.37—39.92	0.10— 1.01
Marine soil.	28	20.61—59.49	1.10—13.10
Forest soil.	18	12.58—48.55	0.08— 1.75

In virgin soil, half of a sample contains total boron 10–20 p.p.m. in dry basis and seventy-five percent of a sample contains it in available form 0.1–0.3 p.p.m.

But in arable soil, sixty-three percent of a sample contains total boron 10–30 p.p.m. and available form 0.1–0.3 p.p.m. In the upper layer (0–10 cm. deep) of arable soil, sixty-three percent of a sample contains available boron over 0.3 p.p.m but in the subsoil (under 10 cm. deep) eighty-three percent of a sample contains it at 0.1–0.3 p.p.m.

The greatest amount of boron in available form is found in marine soil; 1.10–13.10 p.p.m.

As a rule, no definite relation exists between the total and the available amounts of boron. In all samples, except marine soil, the available boron centent is less in the subsoil strata.

As table 2 shows, fertilizer materials of natural origin genarally

contain a high boron content.

Since the boron content of various ashes is constantly high, application of these substances as potassium fertilizer will probably increase the boron content of the soil.

Plants contain varying amounts of boron and the smallest amount is found in cereals. In vegetables, it is present in greater amounts in the tops than in the roots. All sea weeds except one type contain large amounts of boron, but in water weeds, the amount is very small.

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