The Pharma Innovation Journal 2023; 12(1): 1597-1601

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 1597-1601
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www.thepharmajournal.com
Received: 22-10-2022
Accepted: 24-11-2022

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Distribution and characterization of boron in soils of Imphal-West district

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Abstract
Knowledge of different fractions and availability of boron (B) is essential while studying the response of crops to B. Information about the chemistry of B and its bioavailability can be obtained through fractionation of boron. This information helps to predict the environmental impact of boron and predicting its bioavailability, B leaching, B dynamics, B transformation in soils. A total of thirty number of soil sample from thirty different village of Imphal-West District were collected and fractionation of boron were determined through sequential extraction method to find out the distribution and characterization of boron. Status of available boron content of the soil was found low to medium category. On an average, available Boron was found deficient in Imphal-West Dstrict and the most dominant pool of B, contributing about 92.22 per cent towards the total B was the residual pool of B.

Keywords: Boron (B), soil, fractionation, Imphal-West District

1. Introduction
Boron constitutes about 0.001 percent by weight of Earth's crust. B in Indian agriculture has emerged as an important micronutrient and its deficiency was found next only to zinc (Sathya *et al.*, 2009) [22]. Gupta (1993) [8] reported that about one third of the cultivated soils in India are deficient in India and on an average, 18.3% of total cultivated soils in India are deficient in Boron (Shukla *et al.*, 2014). B deficiency are usually found in sandy soil prone to leaching, calcareous soils (>15% calcium carbonate), high pH soils (> 7) and soils which are recently limed (Borkakati and Takkar, 2000; Alloway, 2008) [3, 1]. In the year 1980, boron deficiency was initially reported 2% in India (Katyal and Vlek, 1985) [11], which has now increased to 52% (Singh, 2012) [25]. Most of its deficiency has been widely found in highly calcareous soils of Tamil Nadu, Bihar, Saurashtra and Eastern Uttar Pradesh, sandy soils of Rajasthan and Haryana, hill and sub-mountainous soils of NEH States and north Himalayan and in red and lateritic soils of Karnataka, Orissa, Andhra Pradesh and Kokan region. Sakal *et al*., (1996) [19] reported that about 48% of cultivated soils were deficient in B in calcareous soils of north Bihar. The B deficient soils in India are generally in the eastern states of Assam, Meghalaya, West Bengal, Bihar, Orissa and Jharkhand and cover lateritic and acid red soils in addition to high pH calcareous soils (Behera *et al.*, 2009) [2].
Singh (2001) [24] reported that the contents of hot water soluble B in Indian soils ranged from 0.75 to 8.0 mg kg^{-1}. Deficiencies of B in Indian soils varried from 2% in alluvial soils of Gujarat, to 68% in red soils in Bihar, with a mean of 33% for the whole country (Singh, 2001; Singh 2012) [24, 25]. The highest deficiency of B occurred at 54–86% was recorded in Alfisol soils of West Bengal and Assam, the reason due to increased in rainfall which led to the decrease of water soluble B (Sakal and Singh, 1995) [18].
In soil, Boron is found in five different fractions *viz*. readily soluble, specifically adsorbed, oxide bound, organically bound, occluded or residual B. The relative concentration of these fractions in a soil at a given time depends on properties of soil like pH, amount and nature of clay, lime content, organic matter, soil moisture and plant factors. Only few forms of B are available to plants and their determination is important for evaluating its availability to plants. Padbhushan and Kumar (2017) [16] reported that residual B is the fraction present in soil solution which is absorbed by soil particles weakly, and for plant uptake, it is the most readily available form. It accounts for 1 to 2% of Total boron. The second most plant available form is Specifically adsorbed boron which may be associated with organic matter (OM) or adsorbed

onto clay surfaces or in soil. Most of the research conducted on soil B in India remained confined to the determination of hot water soluble B (Moafpouryan and Shukla, 2002; Sarkar *et al*., 2008) [14, 21], with only few attempts to study the different B fractions (Chaudhary and Shukla, 2004; Datta *et al*., 2002) [4, 5].

Keeping the above points in view, the investigation was conducted to study the distribution of available boron and its different fractions in the soil of Imphal-West district.

2. Materials and Methods

An experiment was conducted to study distribution of different boron fractions in Impal-west district. A total of thirty soil samples (0-20 cm depth) were collected from different paddy growing soils of three sub-division of Imphal-west districts namely Wangoi, Lamsang and Patsoi as shown in Table 1. The soils were dried in shade, grounded and passed through 2 mm nylon sieve. The processed samples were stored in separate polyethylene bags and used for determination of boron fractions through sequential extraction method as described by Raza *et al*. (2002) [17].

Table 1: List of soil samples collected from three sub-division of Imphal-west district of Manipur

District	Name of Blocks	Number of samples
Imphal West District, Manipur	Wangoi	10
	Lamsang	10
	Patsoi	10
	Total number of samples	30
Sl. No.	**Name of Villages**	**Latitude/Longitude/Altitude (Elevation)**
(a) Wangoi sub-division		
1	Phaobakchou	24°33’14.7’’N, 093°52’27.6’’E, 761m
2	Thongam	24°33’16.7’’N, 093°53’03.7’’E, 761m
3	YumnamHuidrom	24°38’37.6’’N, 093°53’58.6’’E, 763m
4	Wangoi	24°40’03.6’’N, 093°53’57.7’’E, 766m
5	Samurou	24°42’24.1’’N, 093°54,09.7’’E, 763m
6	Naran Konjim	24°43’18.5’’N, 093°54’46.8’’E, 769m
7	Hiyangthang	24°43’49.3’’N, 093°54’00.2’’E, 773m
8	Langthabal Phuramakhong	24°44’42.2’’N, 093°54’41.7’’E, 769m
9	Ningombam	24°44’45.8’’N, 093°54’07.6’’E, 769m
10	Kondompokpi	24°44’17.1’’N, 093°53’45.4’’E, 769m
(b) Lamsang sub-division		
1	Howrang	24°49’35.9’’N, 093°51’29.9’’E, 777m
2	Heibongpokpi	24°50’12.4’’N, 093°50’32.7’’E, 783m
3	Lairankabi	24°50’35.0’’N, 093°49’59.0’’E, 785m
4	Phayeng	24°51’15.6’’N, 093°48’56.3’’E, 808m
5	Awanglairenkabi	24°50’53.9’’N, 093°50,16.2’’E, 764m
6	Lamlongei	24°51’34.4’’N, 093°50’20.1’’E, 790m
7	Lairensajik	24°52’33.4’’N, 093°50’19.7’’E, 793m
8	Khurkhul	24°55’19.2’’N, 093°51’21.1’’E, 809m
9	Phumlou	24°52’26.4’’N, 093°51’33.3’’E, 778m
10	Akham	24°50’12.8’’N, 093°51’59.9’’E, 780m
(c) Patsoi sub-division		
1	Patsoi	24°49’40.9’’N, 093°52’01.5’’E, 767m
2	Yurembam	24°47’17.8’’N, 093°51’38.9’’E, 757m
3	Sagoltongba	24°46’57.4’’N, 093°50’53.1’’E, 754m
4	Konthoujam	24°46’09.8’’N, 093°50’42.6’’E, 766m
5	Moidangpok	24°46’06.4’’N, 093°48,51.5’’E, 771m
6	New Keithelmanbi	24°46’06.2’’N, 093°48’02.5’’E, 777m
7	Khumbong	24°46’13.0’’N, 093°50’07.2’’E, 768m
8	Heigrujam	24°44’42.4’’N, 093°48’58.5’’E, 764m
9	Kamong	24°44’35.2’’N, 093°47’56.5’’E, 776m
10	Langing	24°47’34.7’’N, 093°53’27.6’’E, 783m

3. Results and Discussion

The data referring to the distribution and characterization of boron fractions in Manipur of Imphal-west district are presented in the Table 2.

Table 2: Distribution and Characterization of boron fractions in Manipur of Imphal-west district

Villages	Readily soluble B	Specifically adsorbed B	Oxide bound B	Organically bound B	Residual B
Phaobakchou	0.25	0.29	0.37	1.29	38.88
Thongam	0.08	0.10	0.56	1.14	23.91
Yumnam Huidrom	0.10	0.14	0.85	1.06	31.89
Wangoi	0.08	0.10	1.00	1.52	35.74
Samurou	0.16	0.24	1.21	1.25	34.65
Naran Konjim	0.22	0.33	0.46	0.87	35.67
Hiyangthang	0.28	0.44	1.35	1.76	31.18
Langthabal Phuramakhong	0.18	0.27	0.98	1.05	34.15
Ningombam	0.29	0.45	0.40	0.92	33.76
Kondompokpi	0.14	0.20	0.82	1.07	38.66
Howrang	0.10	0.14	0.82	1.11	29.41
Heibongpokpi	0.10	0.13	0.84	1.24	31.71
Lairankabi	0.07	0.09	0.75	1.17	35.39
Phayeng	0.17	0.26	0.55	0.95	18.21
Awanglairenkabi	0.16	0.24	0.46	0.81	23.91
Lamlongei	0.21	0.32	0.56	1.38	31.76
Lairensajik	0.16	0.23	0.73	1.20	35.71
Khurkhul	0.10	0.14	0.60	1.12	35.05
Phumlou	0.35	0.56	1.20	1.63	27.19
Akham	0.31	0.48	1.34	2.67	34.88
Patsoi	0.11	0.15	0.74	1.04	31.64
Yurembam	0.16	0.24	0.80	1.34	31.71
Sagoltongba	0.13	0.18	0.85	1.30	24.90
Konthoujam	0.13	0.19	1.10	1.89	27.85
Moidangpok	0.30	0.48	1.06	1.27	29.31
New Keithelmanbi	0.37	0.58	0.83	1.00	26.89
Khumbong	0.25	0.39	1.80	1.36	24.62
Heigrujam	0.24	0.36	0.84	0.96	28.25
Kamong	0.32	0.51	1.06	1.82	29.52
Langing	0.19	0.29	0.36	1.05	25.77
Mean	0.19	0.28	0.84	1.27	30.74
Range	0.07-0.37	0.10-0.58	0.36-1.35	0.81-2.67	18.21-38.88

3.1 Readily Soluble Boron
Readily soluble boron occupies only a small portion of total boron and it includes dissolved boron plus those absorbed non-specifically on edges of clay and other variable charged surfaces. In the present investigation, the readily soluble boron ranged from 0.07 to 0.37 ppm with a mean value of 0.19 ppm (Table 4.2). The highest (0.37 ppm) value was recorded from New Keithelmanbi village while the least (0.07 ppm) was recorded from Lairankabi village. Similar results have also been reported by other researchers (Chaudhary and Shukla, 2004; Diana and Beni, 2006) [4, 7]. Kasture *et al.* (2020) [10] reported that in soils of Konkan region of India the readily soluble boron ranged from 0.28 to 0.39 ppm. Similar findings were reported by Santhosh (2013) [20] in Kerala soils and suggested that the lower range of readily soluble boron in soil is due to high rainfall and leaching loss.

3.2 Specifically Adsorbed Boron
Specifically adsorbed boron is of great agricultural importance as this fraction along with oxide bound form is in equilibrium with the boron in soil solution. It comprises of boron which is adsorbed on clay minerals. The specifically adsorbed boron ranged from 0.10 to 0.58 ppm with a mean of 0.28 ppm. The lowest content (0.10) ppm was recorded in the soils from Wangoi village and the highest (0.58 ppm) in the soils of New Keithelmanbi village. The overall relative proportion of this fraction worked out to be just 0.85 per cent of total B. This is in agreement with the findings of other workers (Wojcik, 2000; Xu *et al.*, 2001) [26, 27]. Similar findings were also reported by Santhosh (2013) [20] and Nath *et al.* (2018) [15] in the soils of Kerala and Assam respectively.

3.3 Oxide bound
Oxide bound fraction mainly depended upon presence or absence of iron or aluminium oxides and hydroxides as well as organic matter. There will be more adsorption of carboxylic and phenolic groups on the exchange sites present on Al and Fe oxides and their hydroxides due to greater organic matter content, rendering lesser sites for the adsorption of B species (Kaundal *et al.*, 2014) [12]. Perusal of Table 4.2 showed that the oxide bound boron ranged from 0.36 to 1.35 ppm with a mean value of 0.84 ppm. The highest (1.35 ppm) and lowest (0.36 ppm) were found in the soils of Hiyangthang and Langing village, respectively. The results of the investigation are in line with the finding of Kumari *et al.* (2017) [13] (0.26 to 1.67 ppm) in the soils of Himachal Pradesh.

3.4 Organically bound
The organically bound boron ranged between 0.81 and 2.67 ppm with an average value of 1.27. The highest (2.67 ppm) and lowest (0.81 ppm) were found in the soils of Akham and Awanglairenkabi village, respectively. Organically bound boron is considered to be retained by humus in the soil. Organic matter is considered to retain more boron than mineral constituent (Dey *et al.*, 2014) [6] and low temperature restricts the mineralization of organic matter and release of adsorbed boron. Organic carbon content in soils has been reported as the contributor for this fraction (Hou *et al.*, 1994; Chaudhary and Shukla, 2004) [9, 4]. Comparatively higher

range of value in the present study might be due to higher content of organic carbon.

3.5 Residual boron

Residual B was the most dominant pool of B, contributing about 92.22 per cent towards the total B in the present study. Many researchers have reported greater proportion of residual B fraction (more than 90%), irrespective of soil and climatic conditions (Hou *et al*., 1994; Xu *et al*., 2001; Raza *et al*., 2002; Chaudhary and Shukla, 2004) [9, 27, 17, 4]. In the present context, the amount of residual boron varied as 18.21 to 38.88 ppm with a mean value of 30.74 ppm. The highest (38.88 ppm) and lowest (18.21 ppm) were found in the soils of Phaobakchou and Phayeng village, respectively.

Overall the distribution of various fractions in soils of Imphal-west district reveals their relative dominance in the order:

Readily soluble-B>Organically bound-B>Oxide bound-B> Specifically adsorbed-B> Residual-B

4. Conclusion

Status of available boron content of the soil was found low to medium category. On an average, available Boron was found deficient in Imphal-west district and the most dominant pool of B, contributing about 92.22 per cent towards the total B was the residual pool of B. Further studies are required as to find out the various factors causing boron deficiency in the region. Much of the soil itself serves as boron source however the form that is utilizable is very little. Therefore, attention must be paid to those management practices that can convert the unavailable form into available form of boron.

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