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Effect of Submergence on Boron Fractions in Soils of Konkan Region of Maharashtra

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The present study was conducted to examine the effect of submergence on different fractions of boron (B) in soils of Konkan region of Maharashtra. Surface soil samples representing eight soil series namely, lateritic, medium black, *manat*, coarse shallow, coastal alluvial, coastal saline, reddish brown and acid sulphate soil were collected from different places of Konkan region of Maharashtra. The soils were subjected under submergence in pots in laboratory condition for four months equivalent to the life cycle of rice crop. Soil sampling was done at a fixed interval of 30 days and analyzed for different fractions of B. Results showed that under submerged soil conditions, readily soluble, specifically adsorbed, oxide bound, organically bounded and residual B varied from 0.36-1.98, 0.46-2.04, 56.1-57.1, 4.67-4.47 and 188.8-250.5 mg kg^{-1} soil, respectively from 30 days after submergence to 120 days after submergence The observations showed that there were significant changes in all the fractions of B due to submergence thus increasing its availability for plant use.

Key words: Boron fractions, submerged soils, Konkan, Maharashtra

Boron (B), in the form of boric acid or borate, is an essential micronutrient element for plant growth and development (Loomis and Durst 1992). Boron is retained in soils by adsorption on minerals and humic particles and by forming insoluble precipitates (Goldberg and Glaubig 1985). The transport and partitioning of B in soils depend on various soil chemical characteristics including soil pH, type and amount of clay minerals, aluminium-iron (Al-Fe) oxides and oxy-hydroxides, carbonates, cation exchange capacity (CEC) and organic matter (Keren *et al.* 1985; Arora and Chahal 2014). Studies on the distribution of B in different soils as influenced by soil characteristics and management would, therefore, help in developing rational B fertilization schedules for crops. A few schemes for soil B fractionation have been proposed (Jin *et al*. 1987; Hou *et al*. 1996; Datta *et al*. 2002). Widespread B deficiencies in soils have been reported from different parts of the world (Mandal *et al*. 2004; Niaz *et al*. 2013).

In acid soils, soluble B occurs as non-ionised $B(OH)_3$, whereas formation of borate anion $[B(OH)_4]$ takes place with a rise in soil pH. Thus, leaching of B primarily as $B(OH)_3$ under high precipitation regimes and adsorption of soluble B on Al and Fe oxides are the major causes of B deficiency in acid soils (Goldberg and Glaubig 1985). In the present investigation, acidic soils as well as medium black soils were undertaken for the study.

Knowledge of B fractions is fundamental to understand the chemistry of B in soils as it enables to know about binding forms, dynamics, plant availability and possible environmental impacts of B. Boron in the soil is found in different 5 fractions *viz*., readily soluble (solution plus non-specifically adsorbed), specifically adsorbed, oxide bound, organically bound, residual or occluded B. The relative concentration of these fractions in a soil at a given time depends on soil properties like amount and nature of clay, pH, lime status, organic matter, and soil moisture and plant factors. However, only few forms of B are available to plants and their determination is important for its availability to plants. Most of the soil in Konkan region of Maharashtra is lateritic type. It also has different soil types in the small amount *viz*., medium black soil, coastal saline soil, coastal alluvial soil, acid sulphate (Morik) soil, Manat soil, coarse grain soils as well as red brown soil in different parts of the Konkan region of Maharashtra (Anonymous 2008). The rice is the main crop in the Konkan region grown under submerged

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condition. The study on the fractionation of macronutrient as well as some micronutrient has been done on the soils of the Konkan by different scientists. But the information related to the B fractions in the soils of Konkan under submerged condition is scanty. Therefore, the present study was carried out to see the effect of submergence on availability of various fractions of B on soils of Konkan region of Maharashtra.

Materials and Methods

Location and procedure of soil sampling

Eight representative areas were selected based on the different soil types of Konkan region of Maharashtra. The details about the soil series, location and classification are given in table 1. Soil types were collected from 0-15 cm depth using a stainless steel soil auger. The different soil samples were pooled into a bucket and mixed thoroughly to homogenize it. Approximately 25 kg soil sample of each soil from the respective location was collected. Soils were kept under submerged condition in plastic pots with three replications in a completely randomized design in the laboratory of Department of Soil Science and Agricultural Chemistry at College of Agriculture, Dapoli. Four soil samplings were done at 30 days interval, air-dried and ground with the help of wooden pestel and morter.

Soil analysis

Determination of fractions of B was done using sequential extraction method as described by Raza *et al.* (2002).

Readily soluble boron

Soil samples (5 g) were weighed into 50 mL polyethylene centrifuge tubes to which 10 mL of 0.01 M $CaCl_2$ was added and the tubes were shaken at 25 °C for 16 h (Hou *et al*. 1996) after centrifuging at 10,000 rpm for 30 min, the suspension was filtered through Whatman no. 42 filter paper. Boron was determined in clear extracts using Azomethine-H (Bingham 1982) by spectrophotometer.

Specifically adsorbed boron

The residue left from above was extracted with 10 mL of 0.05 M KH_2PO_4 by shaking for 1 h. The suspension was centrifuged and filtered as described previously. After centrifugation, B was measured in the clear supernatant as described in the previous step with the estimation of B by Azomethine-H method.

Oxide bound boron

The residue from the previous step was extracted with 20 mL of 0.2 M acidic NH_4-oxalate, pH 3.25 (Jin *et al*. 1987; Hou *et al.* 1994, 1996) by shaking for 4 h (Hou *et al*. 1994, 1996). Most of these extracts had a yellow to slight reddish colour.

Elimination of colour by treating the extracts with NaOH and $HClO_4$

A 14 mL aliquot of the extract was taken into a 50 mL teflon beaker and the weight of the beaker

Table 1. Details about collected soil samples series, location and classification

Soil type	Physiographic position	Classification (NBSS-LUP Bulletin)
T_1: Lateritic soil	Farm of SSAC, College of Agriculture, Dapoli	Loamy-skeletal, mixed, isohypothermic, Typic Haplustepts
T_2: Medium black soil	Regional Agricultural Research Station, Karjat, District Raigad	Fine-loamy, mixed, isohypothermic, Typic Haplustepts
T_3: Manat soil	Krishi Vigyan Kendra, Roha, District Raigad	Clayey-skeletal, mixed, isohypothermic, Typic Haplustepts
T_4: Coarse shallow soil	Farmer's field at Asud village, Taluk Dapoli, District Ratnagiri	Loamy, mixed, isohypothermic, Lithic Ustorthents
T_5: Coastal alluvial soil	Farmer's field at Murud village, Taluk Dapoli, District Ratnagiri	Loamy, mixed, isohypothermic, Lithic Ustorthents
T_6: Coastal saline soil	Kharland Research Station, Panvel, District Raigad	Loamy, mixed, isohypothermic, Typic Haplustepts
T_7: Reddish brown soil	Farm of College of Agriculture, Saralgaon Taluk Murbad, District Thane	Loamy, mixed, isohypothermic, Lithic Ustorthents
T_8: Acid sulphate (Morik) soil	Farmer's field at Ubhadanda village, Taluk Vengurle, District Sindhudurg	Fine, mixed, isohypothermic, Typic Haplustepts

plus aliquot was noted. The content was then warmed on a hot plate and 2 mL of 5 *N* NaOH solution was added to completely precipitate the dissolved Fe as $Fe(OH)_3$ (Jackson 1973). The beaker with the aliquot was weighed again and the loss in weight was made up by adding distilled water. While doing so, the weight of the 2 mL 5 *N* NaOH was also taken into account. The suspension was filtered through Whatman no. 42 filter paper and thus Fe was separated. A 9 mL aliquot of the filtrate was taken into a 50 mL teflon beaker and 4 mL concentrated H_2SO_4- and 1 mL $HClO_4$ (60%) were added and heated on hot plate at 135±5 °C to destroy the organic matter. Heating of the samples were done at temperature < 140 °C to prevent the B losses (Hou *et al.* 1996). Care was also taken not to allow the samples to dry because B losses have been reported under these conditions (Hou *et al*. 1996). When the volume was reduced to about 6 mL, $HClO_4$ was added in an increment of 0.5 mL until the solution becomes colourless and the volume reduced to 4 to 5 mL. The content was then transferred to a 15 mL graduated polyethylene tube and the final volume was made up to 6 mL. After centrifuging at 10,000 rpm for 15 min, B in the clear extracts was determined by the carmine method using H-30 methine (Bingham 1982).

Organically bound boron

The residue from the above was extracted by adding 3 mL of 0.02 *M* HNO_3 and 5 mL of 30% H_2O_2 at pH 2. The mixture was heated at 85 °C in a water bath for 2 h with the occasional agitation. A second lot of 3 mL aliquot of 30% H_2O_2 (at pH 2) was then added and the sample was heated again to 85 °C for 3 h with intermittent agitation. After cooling, 5 mL of 3.2 *M* ammonium acetate in 20% nitric acid was then added to the solution, which was then diluted to 20 mL with water, mechanically shaken for 30 min and separated by centrifugation.

Residual boron

The residue from the above was transferred to a PTFE beaker to which 5 mL of aqua regia and 5 mL of HF was added. The beaker was placed on a hotplate at 140 °C and evaporated to a volume of 1-2 mL. Care was taken not to allow the digest solution to dry. The procedure was repeated with further 5 mL of each acid. A solution of 10 mL of $AlCl_3$ was then added and the solution was warmed at 60 °C in a water bath for approximately 5 min. The suspension was allowed to cool, transferred to a 50 mL polyethylene volumetric flask and made up to volume. The solution from the volumetric flask was filtered through a Whatman membrane filter paper and the filtrate was collected for B analysis.

Statistical analysis

The data have been subjected to appropriate method of statistical analysis as described by Panse and Sukhatme (1967). Interpretation of result was based on 'F' test. The comparison among means was made by calculating critical difference (CD) at 1% level of significance with the help of SAS software.

Results and Discussion

Initial soil properties

The initial status of the soil physiochemical properties along with the B fractions in the different soils of Konkan region of Maharashtra are presented in table 2.

The initial soil samples showed pH variations from 4.5 to 7.39 with an average value of 6.29 (Table 4). Highest pH (7.39) was recorded in medium black

Table 2. Initial status of physicochemical properties and different boron fractions in soils of Konkan

Tr. No.	Physicochemical properties			Boron fractions (mg kg^{-1})					
	pH	EC (dS m^{-1})	OC (g kg^{-1})	RsB	SaB	OxB	OrB	ReB	TB
T_1: Lateritic soil	5.63	0.09	18.0	0.34	2.58	54.8	4.93	88.3	151.0
T_2: Medium black soil	7.39	0.23	9.1	0.28	2.18	56.9	5.21	83.3	148.0
T_3: Manat soil	6.83	0.08	9.5	0.28	1.93	59.2	5.10	85.9	152.5
T_4: Coarse shallow soil	6.83	0.10	24.4	0.31	1.99	57.2	5.77	87.3	152.6
T_5: Coastal alluvial soil	5.90	0.19	23.7	0.34	2.49	57.0	6.72	81.0	147.6
T_6: Coastal saline soil	7.24	1.11	10.7	0.39	2.52	71.1	6.10	81.5	161.7
T_7: Reddish brown soil	6.03	0.13	15.5	0.34	2.38	59.6	5.15	89.3	156.8
T_8: Acid sulphate soil	4.50	0.10	7.5	0.31	2.35	54.9	4.93	88.8	151.3
Mean	6.29	0.13	14.8	0.32	2.30	58.9	5.49	85.7	152.7

*RSB = Readily soluble B; SaB = Specifically adsorbed B; OxB = Oxide bound B; OrB = Organically bound B; ReB = Residual B; TB = Total B soil followed by coastal saline soil (7.24), manat soil and coarse shallow soil (6.83) while minimum pH was observed in acid sulphate soil (4.5).

The EC values ranged from 0.08 to 1.11 dS m^{-1} having maximum value of EC in coastal saline soil (1.11 dS m^{-1}) and minimum in manat soil (0.08 dS m^{-1}) with mean value of 0.25 dS m^{-1}.

The OC content in soils under study ranged from 7.5 to 24.4 g kg^{-1} with a mean OC content of 14.8 g kg^{-1} (Table 2). Coarse shallow soil recorded highest (24.4 g kg^{-1}) OC followed by coastal alluvial soil (23.7 g kg^{-1}) while acid sulphate soil exhibited minimum value of OC (7.5 g kg^{-1}).

The data pertaining to the content of native B fractions (Table 2) in different soils under investigation showed that readily soluble, specifically adsorbed, oxide bound, organically bound, residual and total B were 0.28 to 0.39, 1.93 to 2.58, 54.8 to 71.1, 4.93 to 6.72, 81.0 to 89.3 and 147.6 to 161.7 mg kg^{-1} with mean values of 0.32, 2.30, 58.9, 5.49, 85.7 and 152.7 mg kg^{-1}, respectively. Readily soluble B was found to be minimum in both medium black and manat soil (0.28 mg kg^{-1}) and maximum in coastal saline soil (0.39 mg kg^{-1}).

Submergence study

Effect of submergence on readily soluble B

Data (Table 3) showed that coastal saline and medium black soil recorded maximum and minimum values of readily soluble B at 30 days of submergence, respectively. It ranged from 0.27 to 0.49 mg kg^{-1} showing mean value of 0.36 mg kg^{-1}. As the submergence period continued till 60 days, the readily soluble B fraction was found to be increased and it varied from 1.71 to 2.51 mg kg^{-1} with an average value of 2.14 mg kg^{-1}. The soil that showed the highest content of readily soluble B was coastal alluvial soil while minimum readily soluble B content was seen in medium black soil at 60 days of submergence. With the advancement of submergence up to 90 days, the soils showed slight decrease in the average value of readily soluble B content as compared to the readily soluble B content at 60 days of submergence. At 90 days of submergence, coastal saline and coastal alluvial soil recorded maximum and minimum values of readily soluble B, respectively. It ranged from 1.90 to 2.23 mg kg^{-1} showing mean value of 2.07 mg kg^{-1}. At the end of the submergence, coastal saline soil recorded highest value of readily soluble B showing similarities with the readily soluble B status of soils at 90 days of submergence. Data revealed that at 120 days of submergence, readily soluble B content varied from 1.61 to 2.14 mg kg^{-1} with a mean value of 1.98 mg kg^{-1}. Further, the least content of readily soluble B was seen in acid sulphate soil. In general, it was observed that initially there was increase in the readily soluble B values up to 60 days period of submergence thereafter it was found to decrease.

Effect of submergence on specifically adsorbed B

At 30 days of submergence the specifically adsorbed fraction showed highest value of 0.57 mg kg^{-1} in coastal saline soil and lowest value of 0.37 mg kg^{-1} in medium black soil with mean value of 0.46 mg kg^{-1}. At 60 days of submergence, acid sulphate and reddish brown soil recorded maximum and minimum values of specifically adsorbed B, respectively which ranged from 1.76 to 2.28 mg kg^{-1} having mean value of 2.05 mg kg^{-1}. The specifically adsorbed fraction at 90 days of submergence ranged from 1.44 to 1.99 mg kg^{-1} with an average value of 1.70 mg kg^{-1}. A critical look on data further revealed that manat soil (1.99 mg kg^{-1}) registered the highest (1.99 mg kg^{-1}) specifically adsorbed fraction. At 90 days of submergence, the lowest (1.44 mg kg^{-1}) specifically adsorbed fraction of B (1.44 mg kg^{-1}) was seen in the coarse shallow soil. At 120 days of submergence, it varied from 1.83 to 2.20 mg kg^{-1} with a mean value of 2.04 mg kg^{-1}. At 120 days of submergence, coarse shallow soil recorded the highest value of specifically adsorbed fraction of B (2.20 mg kg^{-1}), while, acid sulphate soil recorded the lowest content of specifically adsorbed B (1.83 mg kg^{-1}) at 120 days of submergence.

Effect of submergence on oxide bound B

The data (Table 3) revealed that the average value (56.1 mg kg^{-1}) of oxide bound B at 30 days of submergence was less than that observed in the initial oxide bound status (58.9 mg kg^{-1}) of the soil. The soils under submergence showed variations in oxide bound B from 54.4 to 57.5 mg kg^{-1} with an average value of 56.1 mg kg^{-1}. Lowest content of oxide bound B was recorded in the lateritic soil while reddish brown soil exhibited highest value for the same at 30 days of submergence. On continuation of the submerged condition up to 60 days, it was observed at that soils under investigation recorded a slight build-up in the oxide bound B than that recorded in the soils at 30 days of submergence. However, the average value of oxide bound B was found to be decreased at 60 days of submergence. Highest value of oxide bound B was registered in the medium black soil (64.5 mg kg^{-1}) and lowest value was recorded in

Table 3. Periodical effect of submergence on different boron fractions in soils of Konkan

Tr. No.	Readily soluble B (mg kg^{-1})				Specifically adsorbed B (mg kg^{-1})				Oxide bound B (mg kg^{-1})			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T_1 : Lateritic soil	0.38	2.06	2.17	2.04	0.53	1.96	1.87	1.94	54.4	55.0	57.2	58.2
T_2 : Medium black soil	0.27	1.71	2.12	2.12	0.37	2.03	1.91	2.11	55.2	64.5	59.2	59.1
T_3 : Manat soil	0.33	2.14	2.03	2.13	0.44	2.14	1.99	1.98	56.2	61.9	61.9	59.8
T_4 : Coarse shallow soil	0.37	2.15	2.06	2.10	0.46	2.24	1.44	2.18	57.4	55.8	62.1	54.9
T_5 : Coastal alluvial soil	0.31	2.51	1.90	2.01	0.45	2.04	1.58	2.20	57.3	50.8	64.2	56.1
T_6 : Coastal saline soil	0.49	2.14	2.23	2.14	0.57	1.95	1.61	2.14	56.4	52.9	56.6	57.1
T_7 : Reddish brown soil	0.40	2.31	2.03	1.72	0.45	1.76	1.65	1.92	57.5	62.5	61.6	55.4
T_8 : Acid sulphate soil	0.34	2.10	2.05	1.61	0.37	2.28	1.54	1.83	54.7	56.2	50.1	56.2
Mean	0.36	2.14	2.07	1.98	0.46	2.05	1.70	2.04	56.1	57.5	59.1	57.1
SE±	0.07	0.06	0.09	0.06	0.05	0.05	0.17	0.08	2.2	2.5	5.6	1.3
CD (P=0.01)	0.19	0.19	0.25	0.16	0.15	0.16	0.50	0.22	6.4	7.3	16.4	3.9

Tr. No.	Organically bound B (mg kg^{-1})				Residual B (mg kg^{-1})				Total B (mg kg^{-1})			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T_1 : Lateritic soil	2.41	4.26	3.73	4.74	193.4	167.6	230.9	207.9	251.1	230.9	295.9	275.0
T_2 : Medium black soil	5.67	5.19	3.77	4.13	188.3	158.6	204.8	201.4	249.9	232.0	271.8	268.8
T_3 : Manat soil	5.26	4.80	4.09	5.28	195.2	175.9	223.0	219.5	257.4	247.0	293.1	288.7
T_4 : Coarse shallow soil	5.26	4.65	4.24	4.37	193.1	174.7	226.2	207.3	256.6	239.6	296.1	270.9
T_5 : Coastal alluvial soil	6.37	6.25	4.14	4.16	193.5	194.9	172.4	215.4	258.0	256.5	244.3	279.9
T_6 : Coastal saline soil	4.03	4.78	4.41	4.46	187.7	190.6	197.5	170.8	249.2	252.4	262.4	236.7
T_7 : Reddish brown soil	4.31	5.30	4.74	4.41	175.6	185.6	217.3	200.8	238.2	257.6	287.4	264.2
T_8 : Acid sulphate soil	3.86	4.74	3.77	4.20	183.9	198.0	182.1	215.6	243.2	263.4	239.6	279.5
Mean	4.65	5.00	4.11	4.47	188.8	180.8	206.8	204.8	250.5	247.4	273.8	270.5
SE±	1.37	0.19	0.37	0.17	9.2	7.4	20.8	3.7	9.9	8.0	20.7	3.6
CD (P=0.01)	4.01	0.56	1.09	0.49	26.9	21.8	60.8	11.0	29.1	23.5	60.7	10.6

DAS: Days after submergence, Total B is taken as sum of individual B fractions.

coastal alluvial soil (50.8 mg kg^{-1}). Oxide bound B at 60 days of submergence varied from 50.8 to 64.5 mg kg^{-1} giving an average value of 57.5 mg kg^{-1}.

The oxide bound B content of the soils at 90 days of submergence was found to be lowest in acid sulphate soil (50.1 mg kg^{-1}) and highest in coastal alluvial soil (64.2 mg kg^{-1}) with mean value of 59.1 mg kg^{-1}. Coarse shallow soil (54.9 mg kg^{-1}) and coastal alluvial (59.8 mg kg^{-1}) soil recorded lowest and highest content of oxide bound B at 120 days of submergence, respectively. It might be because of high organic matter content in both soils.

Effect of submergence on organically bound B

During the initial period of 30 days, the organically bound B showed highest value of 6.37 mg kg^{-1} in coastal alluvial soil and lowest value of 2.41 mg kg^{-1} in lateritic soil with mean value of 4.65 mg kg^{-1}. A slight increase in average value of organically bound B at 60 days was observed than 30 days of submergence. Data showed variations in the organically bound B at 60 days of submergence ranging from 4.26 to 6.25 mg kg^{-1} with mean value of 5.00 mg kg^{-1}. Data further showed that lateritic soil recorded least content of organically bound B while it was highest in coastal alluvial soil. At 90 days of submergence, the values of organically bound B varied between 3.73 and 4.74 mg kg^{-1}, being lowest in lateritic soil and highest in reddish brown soil with mean value of 4.11 mg kg^{-1}.

At 120 days of submergence, average value of organically bound B recorded by the soils showed slight increase than observed at 90 days of submergence, but was lower than the organically bound B status of initial, 30 and 60 days of submergence. The soils under investigation recorded values of organically bound B between 4.13 and 4.74 mg kg^{-1}, lowest being in medium black soil and highest in manat soil with mean value of 4.47 mg kg^{-1}. An overall scenario regarding effect of submergence on organically bound B illustrated that organically bound B did not record any stable periodical change during submergence period. Initially, at 30 days of submergence, its value increased thereafter not much significant change was recorded in the organically bound B values. Retention of B onto soil was found because of adsorption onto mineral and humid particles and by forming insoluble precipitates (Couch and Grim 1968; Goldberg and Glaubig 1985; Evans 1987).

Effect of submergence on residual B

Soils at 30 days of submergence showed the variations in the residual B values that ranged from 175.6 (reddish brown soil) to 195.2 mg kg^{-1} (manat soil) with mean value of 188.8 mg kg^{-1}. It was found that at 60 days of submergence the highest residual B was recorded in the acid sulphate soil and lowest in medium black soil which was ranged from 158.6 to 198.0 mg kg^{-1}. At 60 days of submergence, average residual B value (180.8 mg kg^{-1}) was lower than that of the value registered at 30 days of submergence. The soils under investigation recorded variations in the residual B values ranging from 172.4 mg kg^{-1} (coastal alluvial soil) to 230.9 mg kg^{-1} (lateritic soil) with mean value of 206.8 mg kg^{-1} at 90 days of submergence. Coastal saline soil (170.8 mg kg^{-1}) and manat soil (219.5 mg kg^{-1}) soil recorded lowest and highest content of residual B at 120 days of submergence, respectively. Soils exhibited variations in the residual B from 170.8 to 219.5 mg kg^{-1} with mean value of 204.8 mg kg^{-1}. At 120 days of submergence, the average value of residual B was higher than the average values recorded at 30 and 60 days of submergence as well as in the initial soil samples. However, it was lower than the average value seen at the 90 days of submergence. Hou *et al*. (1994) reported that the major portion of B in soils existed as residual or occluded forms which accounted for 91.1 to 99.2% of total B with a mean of 97.1%. They also reported that residual fraction of B constituted as much as 99.0% of the total B in some soils of Ontario.

Effect of submergence on total B

In case of total B, its values were obtained by adding values of all the B fractions. The residual B at 30 days of submergence, showed highest value of 258.0 mg kg^{-1} in coastal alluvial soil and lowest value of 238.2 mg kg^{-1} in reddish brown soil with mean value of 250.5 mg kg^{-1}.

A slight decrease in total B than the earlier stage was recorded in case of the average value of total B at 60 days of submergence. Total B at 60 days of submergence ranged from 230.9 to 263.4 mg kg^{-1} with mean value of 247.4 mg kg^{-1}. Data further showed that lateritic soil recorded lowest content of residual B while it was highest in acid sulphate soil. At 90 days of submergence, total B varied from 239.6 to 296.1 mg kg^{-1} with mean value of 273.8 mg kg^{-1} (Table 3). Highest total B was recorded in coarse shallow soil and that of lowest in acid sulphate soil. The average value of total B at 90 days of submergence was highest amongst the average values recorded at 30, 60 and 120 days of submergence. At 120 days of submergence, highest value total B content of 288.7 mg kg^{-1} was recorded in manat soil while least in coastal saline soil. Total B content of the soils showed variations from 236.7 to 288.7 mg kg^{-1} with mean value of 270.5 mg kg^{-1} at 120 days of submergence.

Conclusions

In this experiment, soils under submergence showed significant changes in B fractions. Readily soluble B is the easily available fraction of B for plant use. Under submerged condition availability of readily soluble B increases to the levels that can be taken up by plants. Residual B fraction contributed approximately 70 to 75% in total B present in the soils under submerged condition. The study indicated that in the region having high rainfall and soils under oxidized condition, there is no need to add boron during *kharif* season especially for rice and *kharif* vegetables because of increase in the B fractions which was recorded in the study. .

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