STATUS OF TOTAL BORON AND BORON IN LEAF SAMPLES - STUDY DONE IN COASTAL ANDHRA PRADESH

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ABSTRACT

The study focuses on soil system concepts, boron availability, and crop plant roles. Numerous researchers have looked into the physico-chemical parameters and availability of the element boron. How irrigation and fertilizers affect soil concentration and depth distribution This study used ICP-MS and AAS to analyze boron concentration. For two seasons, 40 soil samples were used to study the interaction of boron with other micronutrients and its availability depending on physico-chemical parameters. Total boron and leaf boron content were explained for soil samples and analyzed for standard parameters. AAS, total boron in soil, and leaf samples using ICP-MS have been extensively discussed. Sampling site 1 had more low-boron samples than sampling site 2. Leaching explains this since rice fields had the lowest values. Few fields in the study area had sufficient, deficient, or toxic soil boron levels. Leaf samples had enough boron. Crop growth and yield decreased due to a deficiency of boron. Boron is essential for yield and growth. On boron-deficient soils, crop yield is affected by boron fertilizer timing, method, source, rate, and nutrient balance. Agronomic methods improve plant B status. Aeration and organic matter decomposition release adsorbed B. Crop rotations increase soil organic matter and cation exchange capacity, increasing B availability. Diagnosing boron deficiency and toxicity, understanding its interactions with other nutrients, and applying boron fertilizers effectively will boost crop productivity.

KEY WORDS
Boron, micronutrients, deficiency, fertilizers, agriculture, parameters, healthy, samples, toxicity, efficiency, availability.

INTRODUCTION

Climate of Andhra Pradesh and its soil type are suited well for agriculture and many varieties of crops are cultivated here. Depletion of natively available nutrients, micronutrients are observed due to the usage of varieties that give high yields and using high analysis fertilizers for longer time periods (Mostafa Mohamed Selim et al.,2020). Removal of nutrients continuously with no replacement leads to stress in plants and loss of yield. So, it's very important to evaluate soil arable position as it is the foremost parameter to determine the soil productivity level (Tilahun, G. et al., 2007). Boron belongs to metalloid group of elements and has properties that lie between metals and non-metals. The boron requirement in dicotyledons is more than any other nutrients on a molar basis(Milka Brdar-Jokanovi´ et al.,2020).Cereals like maize, rice, wheat, sorghum etc are considered to be less sensitive to deficiency of boron (Rashid et al.,2004). Plants have variations in their boron requirement and a very narrow difference is observed between boron toxicity and deficiency. The amount of boron absorbed by plants is neither toxic nor it is available to plants directly (Keren et al., 1958). Keeping in view of the fact that the information regarding boron status in agricultural soils is very less and almost negligible in the state, these studies may help to get some information on the boron distribution in soil as well as factors responsible to control its availability in soils, an attempt has been made to focus on the boron level and other trace elements in some selected areas of Visakhapatnam region of Andhra Pradesh.

Study Area:

The state of Andhra Pradesh (12°41' and 19°07' north latitude and 77° and 84°40' east longitude) is located in south in southeastern part of India. The present study has been carried out in Visakhapatnam district (17°6904' latitude, 83°231' longitude) and its annual rainfall is 1202mm. The rice grown soil samples were collected from Deverapalli Mandal (18°02205' latitude, 83°00958' longitude) which receives annual rainfall of 1008 mm, this is taken as sampling site - 1. Sugarcane grown soil samples were collected from Taruva village (17°9460' latitude,82°9764' longitude) this is also taken as sampling site-1, most of the soils in these areas are black soils. The crop rotation is done for every six months and puddled fields where water is stored are used for paddy cultivation. The vegetables grown soil samples were collected from Cheemalapalli area in Chintala Agraharam Village located in Pendurthy Mandal. The coordinates of Pendurthy Mandal are (17.8333 °N, 83.2000 °E). This is taken as sampling site-2. vegetable cropping is done continuously throughout the year and red soils are predominant in this area (Usha Chirala & Bhavana Pedada et al.,2020)

LITERATURE SURVEY

Role of B in plant

In different plant growth functions, boron is implicated indirectly or directly and in various cultivated plants, flowering, pollination, seed development, and sugar transport through plant organs are carried by this nutrient (Blevinsm and Lukaszewski et al., 1998). Boron affects growth in plants significantly as it has a special role in transport of sugar (Miwa et al.,2008),

Boron toxicity

The most important source of trace elements in plants is water. The toxic concentrations of trace elements in plants, such as B, may be directly due to water from a particular well or indirectly to the land use of wastewater and the soil in which B is highly available (Kubota et al., 1980). In dry lands of South Australia, soils of USSR, India, Israel, and Lake California are few areas where high soil boron is found.

Symptoms of B deficiency and toxicity

Marginal and tip chlorosis are the most prominent symptoms of B deficiency. Boron deficit symptoms appear at the terminal bud and youngest leaves as retarded growth or necrosis resulting in the regeneration of numerous auxiliary buds producing a busy growth and slight thickening of leaves. Usually, leaf blades are misshaped, internodes are shorter and, an increase in diameters of stem and petioles are observed. Tip burn, and brown- or black heart in heads of vegetable crops, Water-soaked areas are also the symptoms of B deficiency. Besides the failure of seed and fruit set, the conditions of fruits are affected (Singh et al., 2006).

Distribution of total boron in soils depending on depth:

In some sugarcane grown alluvial soils of Bihar, there was an upward accumulation of total boron where as downward accumulation of total boron was observed in calcareous profiles (Soni et al.,1961). When working with Rajasthan soils, subsurface accumulation of boron was noticed in irrigated soils and surface accumulation of boron was noticed in unirrigated soils by (Mathur et al.,1964). Irrigated soils had more total boron than unirrigated soils. The total boron content decreased inversely with depth in Uttar Pradesh soils as reported by (Singh and Singh et al.,1966).

MATERIAL AND METHODS

Sampling and Preparation:

Soil sampling was done during the month of March from the agricultural fields under rice and sugarcane cultivation. Sampling was done in zig-zag pattern and from each field at least 10 sub samples were collected from 0 – 15 cm distance inwards in 'V' shape and were mixed to form a complex sample. These samples were stored in polyethene sacks and were brought to laboratory, samples were air dried, grounded and passed over 2 mm sieve and stored for micronutrient study. The rice sample and sugarcane samples are coded as 'D' for season-1 and '2D' for season-2. Similarly pendurthy samples were coded as 'P' for season -1 and '2P'for season-2.

Analysis of Total Boron (ICP-MS):

Sample preparation by microwave digestion:

The concentration of total boron present in the soil samples were measured by Agilent Technologies 7800 ICP-MS instrument with quadrapole mass analyzer and using Mass hunter software.

Analysis:

1) The ICP-MS instrument was standardized as per the operational manual.
2) Minimum of five standards were aspirated in increasing order of concentration and calibration curve was prepared between concentration and intensities and the range of estimation was set as it varies from element to element.
3) The sample is aspirated into plasma torch of ICP-MS and the intensities were measured and compared with standard solution at characteristic masses of the respective element.
4) Finally blank was aspirated which was used as a diluent.

3.5.15 Analysis of Leaf sample:

Digestion process:

The microwave digestion in closed vessel of plant sample(leaf) using HNO_3 and H_2O_2mixture or only HNO_3 is favourable for trace element analysis by ICP-MS. 0.5gms of leaf sample was weighed and 5.0 ml of concentrated $HNO_3$and 5.0 ml of $H_2O_2$was added in a vessel. The samples were left for pre-digestion for overnight at room temperature and the vessels were sealed with caps and inserted into rotor. The rotor was loaded into microwave digester and the process of digestion was started as per the programme. After digestion the vessels were kept for cooling and the solutions were made upto the mark with deionised water after transferring it to a 25ml volumetric flask. The solutions were filtered with whatman 42 number filter paper and then the solution was ready for aspiration into ICP-MS instrument. The same procedure was followed for blank preperation without sample. For the above analysis Anton Paar multiwave GO microwave digestion system which has unique cooling times by turbo cooling process as short as 8 minutes for fully loaded 12 position rotor was used.

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RESULTS AND DISCUSSION

Soil Total Boron

Table.No.1.1(a) Determination of Total Boron in soil samples from sampling site-1 for two seasons.

Sample no	Season-1 total B (ppm)	Season-2 total B(ppm)
D1	11.5	10.95
D2	13.9	11.67
D3	10.84	10.41
D4	12.93	10.73
D5	11.27	12.8
D6	15.43	10.78
D7	10.35	13.1
D8	11.48	13.32
D9	12.53	11.27
D10	10.12	14.08
D11	10.81	9.52
D12	12.91	11.22
D13	11.7	10.0
D14	12.74	12.13
D15	11.85	9.83
D16	13.7	12.1
D17	13.88	14.09
D18	13.22	13.28
D19	13.09	16.36
D20	12.23	18.33
D21	9.89	18.84

D22	12.72	18.95
D23	10.34	12.36
D24	12.86	13.72
D25	14.29	12.62

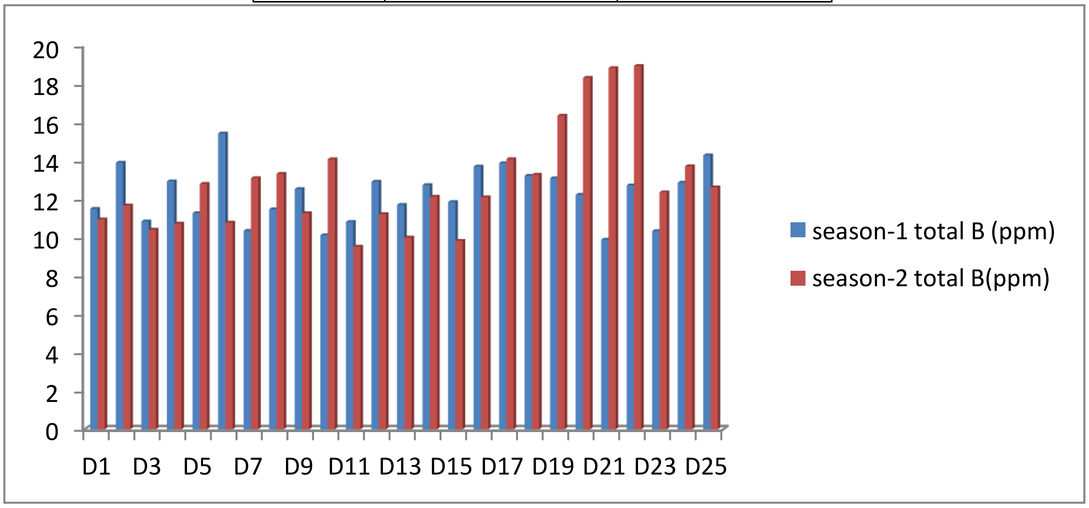

Figure 1.1 (a) Bar graph for determination of Total Boron in soil samples from sampling site -1 for two seasons.

Table No.1.1 (b) Determination of Total Boron in soil samples from sampling site-2 for two seasons.

Sample Code	Season-1 total B (ppm)	Season-2 total B (ppm)
P1	14.16	12.919
P2	18.987	12.512
P3	13.78	13.209
P4	19.841	12.821
P5	15.485	22.317
P6	17.465	12.796
P7	18.445	16.272
P8	16.865	14.933
P9	12.897	14.636
P10	16.418	12.558

P11	13.889	12.401
P12	13.93	14.549
P13	15.534	16.192
P14	18.445	16.832
P15	13.752	12.45

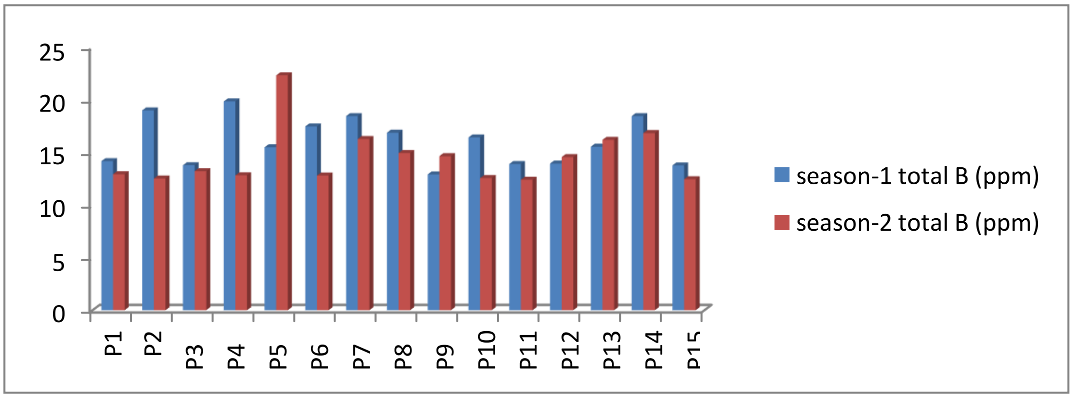

Figure 1.1 (b) Bar graph for determination of Total Boron in soil samples from sampling site-2 for two seasons.

Supply of B from the soil is affected greatly by a dominant factor that is parent material, as soils show great variability in their clay and boron forming minerals. Arid region soils and semi arid regions soils formed from igneous rocks have low concentration of boron when compared to soils formed from sedimentary rocks. The range of total boron content is 2 to 200 mg/ kg but only 3 to 5% very less fraction is available to crops. Total soil boron is present as a component of mineral tourmaline. In world soil total boron content ranges from 9 - 85 mg/ kg and in Indian soil from 2.8 to 630 mg/ kg. In the present study, the total boron in the soil samples from site-1 had values from 9.89-14.2ppm with mean 12.26ppm for season-1; 9.83-18.95ppm with mean 12.89ppm for season-2. In sampling site-2 it ranged from12.89-19.84ppm with mean 15.99ppm for season-1 and for season-2 the range was 12.4 - 22.31ppm with mean14.49 ppm. From the findings it is clear that though good amounts of total boron is present in the study area only little fraction of it is available to crops. Most of the fields in the studied profiles recorded low concentrations of available boron. From the literature it is clear that the boron from tourmaline in soils is not readily available for plant use and few insoluble minerals may have boron as important impurity. It is not reliable to depend on total boron content in soil for boron adequacy for crop growth as only less than5% of total boron becomes available for crops. In our present study when total boron values were compared with available boron it was found that during season-1 the percentage of total boron available to plants ranged from 3.71 % - 43.55 % with mean 0.089 % and during season-2 it ranged from 2.40 % - 51.20 %with mean 0.084 % for sampling site-1. For sampling site-2 the values ranged from 5.20 % - 19.35 % with mean 0.103 % during season-1 and during season-2 it ranged from 5.78 % - 26.20 % with mean 0.094 %.As per the literature it was found that only 5% of total boron was available to plants. An increase in fixation of boron from 48 – 60 % was observed when SOC content increased from 0.5 % - 0.75 %. From this observation it was clear that leaching is prevented when boron is associated with SOC there by increasing its availability to crop plants, though excess percentage of total boron was available to crop plants in our present study many soil samples had low available boron content and this may be due to other environmental factors.

Figure.1.1 (c)Boron toxicity in rice crops

Figure 1.1 (d)Boron deficiency in rice crops

4.6 Boron in leaf sample

Table No.2.1(a) Determination of boron in leaf samples from sampling site-1 and sampling site-2.

Sample no	B (ppm)
P4	21.55
P10	26.03
D1	4.14
D12	5.32
D18	6.05
D25	5.06

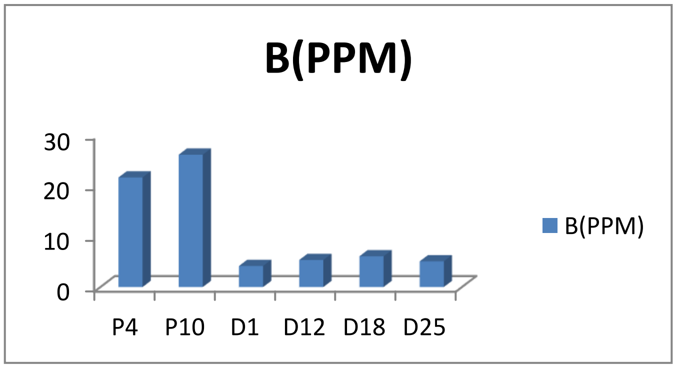

Figure.2.1(b)Bar graph for determination of Boron in leaf samples from sampling site-1and sampling site - 2.

In our present study leaf samples were collected from site specific crop plants and analyzed for boron content. The mean value of 11.358 ppm was observed for boron content and the range was 4.14 ppm - 26.03 ppm. As the critical ranges for leaf content of boron in dicotyledons is given as 20 to 70 mg kg^{-1} in literature and in dried leaf tissues the range was from 10 - 75 m / kg it is clear from our findings that the spinach leaves had boron levels which were sufficient as it comes under dicotyledons group whereas rice and sugarcane belong to the monocotyledon group and had boron between 1 to 6 mg kg^{-1}. So, from the above findings the leaf boron content of crop plants from sampling site 1 and 2 had sufficient levels but less than optimal range.

Plants absorb boron actively in ionic form when soil has low concentrations of boron and translocation of boron takes place in plants by xylem as per the observations of (Bowen et al., 1972, Bowen and Nissan et al., 1977 and Reisenauer et al., 1973). The boron in leaves is accumulated due to Xylem stream, transpiration; leaf veneation was given by (Oertli and Richardson et al., 1970). Gopal et al., 1970 stated that roots which absorb boron is carried by passive stream from roots to leaves as it is not soluble in water, and leaves are the end points of transpiration and considered as the chief organs of plants. In general boron gets accumulated in leaf margins and cannot be redistributed under any conditions (Jones et al., 1972).

Boron availability in plants is affected by different parameters like amendments of soil, types of soil, management practices etc. In soils boron concentration ranges from 2 to 200 mg kg^{-1} but only < 5–10 % of total B becomes available to plants. The forms of boron which plants absorb directly are Boric acid (H_3BO_3) and borate (B $(OH)^{4\,-}$). High pH values result in decline of availability of boron to plants due to high adsorption and at pH > 6.3 soil pH and plant boron have negative interaction with each other which is commonly observed in puddled rice fields. In aerobic rice culture, fluctuation in pH and increase in redox potential changes boron availability which results in adsorption of boron by the oxyhydroxides of Fe or Mn which results due to their oxidation. Plants take up N as NO_3^- instead of NH_4^+due to increase in nitrification process in aerobic soils as a result, pH increases due to increase in OH^- concentration in the rhizosphere resulting in decrease of boron availability to plants. In dry soils the ability of plants to take boron decreases as the mobility to plant roots decreases and so dry soils are likely to be deficient in boron. For leaf growth more B is required for plants grown under high light intensity, when compared to plants grown under low light intensity. Long photoperiods, results in symptoms of deficiency in plants leading to speculation that in plants boron requirement increase with increase in light intensity and also it is found that sensitivity of plants to boron deficiency increases with light intensity. High light situations results decrease in B uptake and its partitioning into actively growing young leaves, translocation from roots to shoots etc. plant B demand increase with Low temperature. Plant B uptake efficiency is reduced due to low root temperature. Deficiency symptoms of B in most plant species is observed due to immobility of B and symptoms become visible in parts of young plant including fruits, flowers, and seeds, apices etc. No toxic effect was observed when amount of boron fertilizer applied is (0.5–1.5 kg B ha^{-1}) in rice–wheat rotations on calcareous soils of Pakistan. Deficiency critical concentration/range (mg B kg^{-1}) suggested by Jones Jr et al., 1991, in rice flag leaves is 6ppm, the values in our present study are (4.14ppm, 5.32ppm) which are less than the critical limits and indicate the low levels of available boron in soils of our study area.

In our present study the results are in line with the above findings. 21% samples had value below the optimal range for B (15.0-20 mg kg^{-1}). Deficit levels of Boron and Zn were reported by Panhwar et al., 2011 which are in accordance with the values of our present study. In our present study the plant leaf tissue boron had values (6.05 ppm, 5.06 ppm) which are above the critical limit but below the optimal range, so our reports are in accordance with the findings of the studies carried out in lower Sindh, Pakistan (M.Y. Arain et al., 2017). As the sufficiency and toxicity level is narrower for boron when compared to other nutrients, it becomes very difficult to set sufficiency, toxicity, and deficiency levels for boron. Plants vary in their requirements for boron like leaf content ranges from 1 - 6 mg kg^{-1} in monocotyledons and in dicotyledons 20 - 70 mg kg^{-1}. The optimum boron levels in dried leaf tissues for many crop plants ranges from 10 - 75mg kg^{-1}. In soil average boron content is 30 mg kg^{-1}, and boron application is advised only when less than 25 mg $kg^{-1}$of boron is present in the leaves. Generally, trace amounts of boron are required by plants but when the concentration exceeds 20 mg kg^{-1} it becomes toxic.

The study area had few fields which were sufficient, few fields which were deficient and very less fields which had toxic levels of boron in soil .But the leaf samples had sufficient amount of boron and application of boron to deficient crops should be monitored properly to avoid toxic affects which results in reduction of good quality and crop yield.

CONCLUSION AND FUTURE SCOPE OF WORK

In the studied soil profiles the total boron in sampling site-1 ranged from 9.89 - 14.2 ppm with mean 12.26 ppm for season-1; 9.83 - 18.95 ppm with mean 12.89 ppm for season-2. In sampling site-2 it ranged from12.89 - 19.84 ppm with mean 15.99 ppm for season - 1 and for season - 2 the range was 12.4 - 22.31 ppm with mean 14.49 ppm. From the findings it is clear that though good amounts of total boron is present in the study area only little fraction of it is available to crops.

In our present study leaf samples were collected from site specific crop plants and analyzed for boron content. The mean value of 11.358 ppm was observed for boron content and the range was 4.14 ppm - 26.03 ppm. So, from the above findings the leaf boron content of crop plants from sampling site 1 and 2 had sufficient levels of boron but less than optimal range.

Crop growth and yield decrease severely due to deficiency of boron. So, for good yield and optimum growth boron nutrition is very important. On boron-deficient soils the crop yield is affected by application process of boron fertilizer, as well as proper nutrient balancing with, boron source, rate of application etc. Adsorbed boron is released in soil by soil aeration and decomposition of organic matter. The crop rotation helps to improve boron availability as well as other properties like SOM and CEC. Soils different properties are altered with the use of organic manures that provide micronutrients as well as other plant nutrients by adding OM to the soil.

In rice growing areas of Asia, quality losses and yield losses have been reported as a result of soil B deficiency where rice is a major staple cereal. Several factors are responsible for boron deficiency, like soil factors and environmental factors resulting in boron deficiency even though significant quantities of B are present. The available Boron concentration was less than 1 ppm in maximum number of fields of Deverapally which can be due to leaching. Good management practices like using organic manure etc are helpful in controlling the mobility and bio-availability of Boron. The sustainability of rice production system in long term can be affected by the deficiency of Boron. So, knowledge of reasons behind the deficient and toxic levels of boron and its relation with different nutrients can improve crop productivity.

The results of our present study will help to create a baseline data to initiate deeper understanding of the regional problem. It will be helpful to find out the degree and type of problems related to soils. Therefore different parameters are to be considered for micronutrient management like soil type, crop type, source and method, the severity of deficiency, time, rates and frequency of application, for maintenance of human health and, for sustainable agricultural production.

FUTURE SCOPE:

1) Different resources should be used to know boron distribution as well as study of its accumulation and knowledge regarding the relationship of boron with different nutrients in soil solution, their availability and boron-enriched fertilizer application in rice crops under flooded and aerobic conditions is to be studied thoroughly.
2) B-deficient rice zones should be explored by using GIS-based mapping to know the boron fertilizer which is suitable and application process adopted to improve its efficiency.
3) In Indian soils boron fertility is depleting at higher rates as a result of intensive cropping of high yielding crop varieties, so boron depletion rate in different soil and crop systems is to be studied to forecast boron deficiencies and to take necessary action .

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