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Status of Sulphur and Boron in Soils of North Gujarat Region of India

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Abstract: The soils of North Gujarat region's were assessed for its Sulphur and Boron status due to its visible deficiency in plants. Study was conducted in three districts *viz.,* Sabarkantha, Mehsana and Patan from which 60, 110 and 52 villages were selected and soils samples were collected with geo-tagging. A total of 1332 surface soil samples (Sabarkantha 360, Mehsana 660 and Patan 312) were collected from these respective districts. Analysis of these soil samples showed a wide variation in soil pH (6.04-9.72) from slightly acidic to alkaline. Organic carbon (OC) content ranged from 1.0 to 7.1 g kg^{-1}, about 90, 65 and 74% of soil samples were found to be under the low OC in Mehsana, Sabarkantha and Patan districts, respectively. Available S content ranged from 1.7 to 68.5 mg kg^{-1} with a mean value of 15.6, 14.7 and 14.9 mg kg^{-1} in Mehsana, Sabarkantha and Patan districts, respectively. S deficiency in soils of all three districts was 18.1, 25.5 and 16.9 per cent, which appeared in medium-fertility class level as per Nutrient Index Value (NIV). The high magnitude of S deficiency was noticed in soils of Idar taluka (43.9 %) followed by Khedbrahma taluka (40.9%) of Sabarkantha district, showing medium-fertility class. Further, these samples were also found deficient in hot water-soluble boron (HWS-B) and it ranged from 0.06 to 3.12 mg kg^{-1} with a mean value of 0.44, 0.45 and 0.44 mg kg^{-1} in districts of Mehsana, Sabarkantha and Patan, respectively. The NIV indicated B fertility level of low to high. Per cent deficiency of B recorded about 29.4, 17.9 and 19.2 per cent in all three districts. A large scale of B deficiency was noticed in Satlaspur taluka (52.4 %) of Mehsana district, which showed low fertility class.

Key words: *Boron, sulphur, nutrient index, Sabarkantha, Mehsana, Patan, deficiency*

Introduction

In India, sulphur (S) and micronutrient deficiencies have been reported with increasing frequencies from intensive, irrigated production systems; and micronutrient deficiencies have been reported to be one of the main causes for yield plateau or even yield decline in irrigated intensified systems (Takkar 1996). Analysis of more than 30,000 soil samples from different parts of Gujarat indicated a widespread deficiency of major, secondary and micronutrients. The soil maps for sulphur and micronutrient deficiencies in Gujarat soils were prepared based on different status categories to show the area, which needs more attention for nutrient application. The soils falling under low and marginal groups need greater attention for supplementing these nutrients to maintain soil fertility status and sustain higher crop productivity (Anonymous 2011).

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Except for sporadic attempts, no systematic study was conducted to assess boron (B) deficiencies in Gujarat's soils. Boron is one of the eight essential micronutrients required for the normal growth of plants. Soils with high clay content (fine texture and greater surface area) or with high organic matter content have great potential to provide more B for plant use and, therefore, are less likely to be deficient, but it is *vice*-versa for sandy textured soil. Most of the total B in soils is found within the soil minerals' crystalline structures and it ranges from 7-80 mg kg^{-1} soil (Krauskopf 1972). However, the total B content in soils has little bearing on the status of available B. Available B (hot water soluble) in Indian soils was found to range from 0.08 to 2.6 mg kg^{-1} and about 33 per cent soils tested to be deficient in B (Singh 2001).

In temperate regions, sulphur is mostly present in organic form (>95%). In the tropical and sub-tropical region, it is present as inorganic sulphates in appreciable amounts. Among Indian soils, only 30% of total S may be in organic combination in alluvial soils (Entisols), but in Mollisols of tarai region, it may be around 70% (Singh *et al.* 2015). Sulphur deficiency is one of the key constraints for the sustainable growth and production of several field crops. Therefore, the significance of S is increasingly accentuated in the recent past because of its deficiency being extensively reported in different parts of India (Tondon and Messick 2007). Based on the above fact, this study was undertaken to find out the availability of sulphur and boron in soils of selected three districts of north Gujarat, which are largely under intensive cultivation due to increased irrigation facilities.

Materials and Methods

Study area

The study was carried out in three districts *viz*. Mehsana, Patan and Sabarkantha of North Gujarat region (Fig. 1). Mehsana district (23.02º to 24.09º N; 71.21º to 75.52º E) with total geographical area is 4,39,300 ha with a mean annual rainfall of 665-875 mm and mean annual temperature is above 28° C. The soils are classified under Inceptisols, Entisols and Aridisols with sandy loam to sand soil texture. The main crops grown in this district are wheat, cotton, castor, pearlmillet, tomato, citrus, okra, mango and cumin. The district consists of nine talukas (Tehsils) *viz.*, Becharaji, Kadi, Kheralu, Mehsana, Vadnagar, Vijapur, Visnagar, Satlasana and Unjha.

The total geographical area of Sabarkantha district is 7,39,000 ha with a mean annual rainfall of 500-1000 mm and mean annual temperature is above 28° C. The soil order of the Sabarkantha district are Inceptisols, Entisols and Aridisols with sandy loam to sand soilt exture. The crops mainly cultivated in the Sabarkantha district are bajara, wheat, cotton, castor, maize and rice. The district consists of thirteen talukas (Tehsils) *viz.,* Bayad, Bhiloda, Dhansura, Himatnagar, Idar, Khedbrahma, Meghraj, Malpur, Modasa, Prantij, Talod, Vadali and Vijaynagar.

Patan district (23.55º to 24.41º N; 71.31º to 72.20º E) with total geographical area is 5,66,755 ha with a mean annual rainfall of 600 mm and mean annual temperature is above 28° C. These are two soil orders in this district *viz.*, Inceptisols and Aridisols with sandy soil texture. The crops mostly cultivated in this district are cotton, bajara, wheat, maize and castor. The district consists of eight talukas (Tehsils) *viz*.,Chanasma, Harij, Patan, Radhanpur, Satalpur, Sami, Siddhapur and Vagdod.

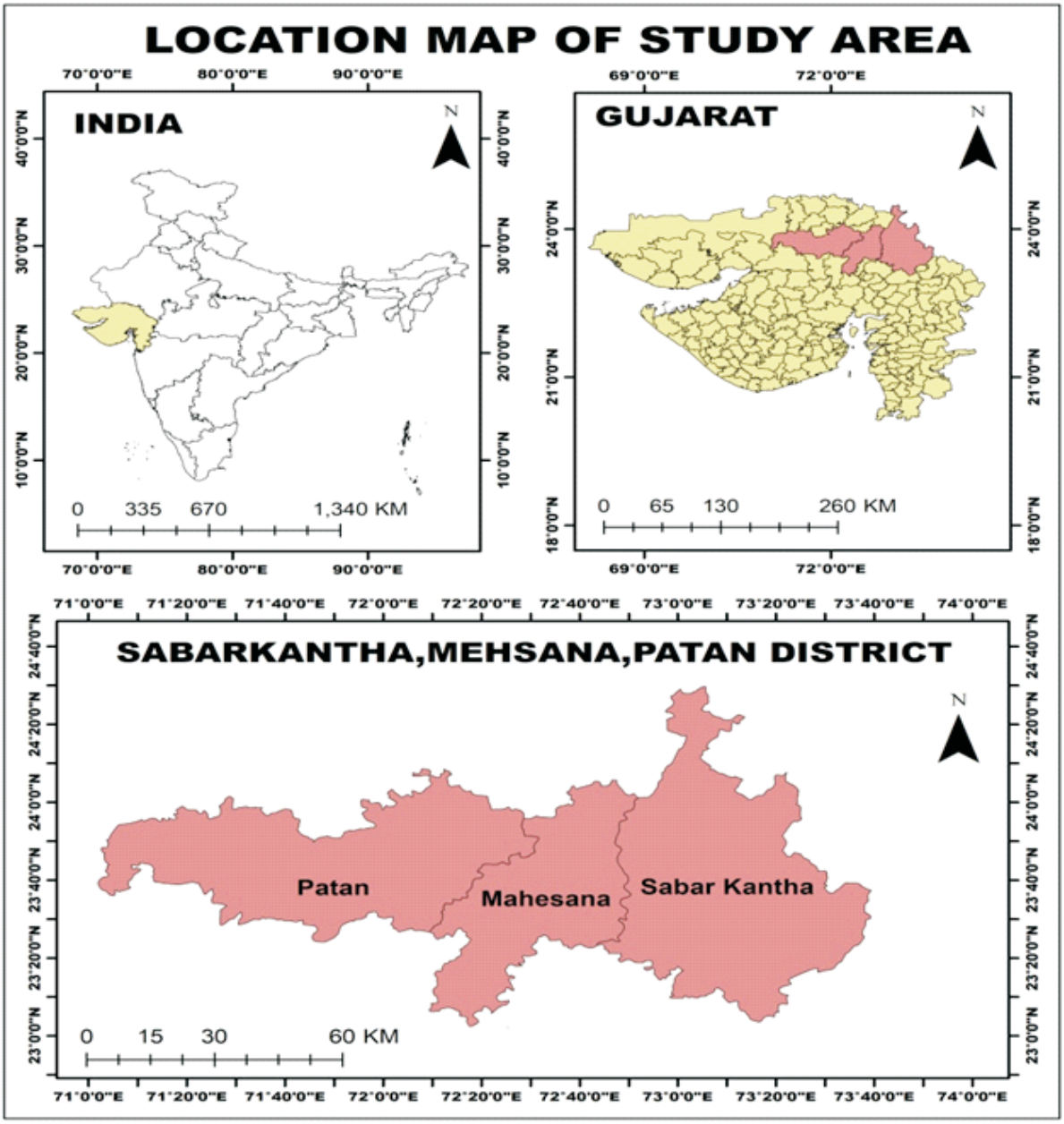

Fig.1. Location map of the study area

Soil sampling

A total of 1332 georeferenced surface soil samples (0-15 cm) were collected using a hand-held global positioning system (GPS) under the project "GPS and GIS-based soil fertility mapping of the selected districts of the country" funded by the Ministry of Agriculture, GOI, New Delhi under the supervision of Indian Institute of Soil Science, Bhopal. These soil samples were in collected randomly from 222 selected villages covering all 29 talukas/tehsils of Mehsana, Sabarkantha and Patan districts of north Gujarat. The soil samples were air-dried, processed with wooden pestle and mortar and sieved by a 2-mm sieve. The soil samples were analyzed for soil reaction (pH) in 1:2.5 soil: water suspension (Jackson 1973); organic carbon (OC) by Walkley and Black method (1934); available S by turbidimetric method-0.15% $CaCl_2$ (Williams and

Steinbergs 1959) and Hot Water Soluble boron by azomethine-H method of John *et al.* (1975). The nutrient index and categorization of available nutrients in low (<1.67), medium (1.67-2.33) and high (>2.33) was workout by the following formula given by Ramamurthy and Bajaj (1969).

$$\text{Nutrient index} = \frac{\{(PL \times 1) + (PM \times 2) + (PH \times 3)\}}{100}$$

Where PL, PM and PH are the percentages of soil samples falling in the category of low, medium and high nutrient status and given weightage of 1, 2 and 3, respectively.

The database on soil available S and B was generated and geocoded thematic maps were prepared in ArcGIS.

Results and Discussion

Descriptive statistical analysis of selected soil properties

The descriptive statistics of different soil properties (Table 1) suggest that there were wide variability in soil pH, EC, OC, S and B in the area. The variation and non-normal distribution of soil properties in the study area may be due to the adoption of different soil management practices, including variation in fertilizer application and other crop management practices at different locations (Srinivasarao *et al*. 2014; Ferreira *et al.* 2015).

Table 1. Overall descriptive statistics of selected soil parameters for all three districts

Parameters	Minimum	Maximum	Mean	Standard Deviation	Standard Error	CV%	Skewness	Kurtosis
Mehsana district(n=360)								
pH (1:2.5)	6.49	9.72	8.01	0.49	0.03	6.14	-0.20	0.89
EC (dS m^{-1})	0.13	1.38	0.36	0.24	0.01	65.23	1.82	3.55
OC (g kg^{-1})	0.97	5.84	3.09	1.28	0.07	41.40	0.29	-1.00
S (mg kg^{-1})	3.24	61.34	15.62	8.26	0.44	52.87	2.28	7.21
B (mg kg^{-1})	0.06	2.49	0.44	0.39	0.02	87.82	2.09	6.18
Patan district (n=660)								
pH (1:2.5)	6.48	9.32	8.01	0.54	0.03	6.74	-0.12	-0.32
EC (dS m^{-1})	0.10	1.97	0.53	0.37	0.02	69.69	1.48	1.89
OC (g kg^{-1})	1.48	6.92	3.95	1.41	0.08	35.70	0.25	-0.83
S (mg kg^{-1})	1.69	31.94	14.92	5.88	0.33	39.39	0.96	0.49
B (mg kg^{-1})	0.08	1.93	0.44	0.31	0.02	70.64	1.94	5.05
Sabarkantha district (n=312)								
pH (1:2.5)	6.04	9.16	7.66	0.62	0.02	8.13	-0.41	0.00
EC (dS m^{-1})	0.10	1.76	0.37	0.24	0.01	64.85	2.05	5.22
OC (g kg^{-1})	1.01	7.14	4.18	1.48	0.06	35.47	-0.14	-0.96
S (mg kg^{-1})	3.90	68.53	14.70	7.81	0.30	53.14	2.48	9.25
B (mg kg^{-1})	0.10	3.12	0.45	0.33	0.01	73.75	2.62	12.48

Soil pH

The pH of the surface soil of the Mehsana district ranged from 6.49 to 9.72 and about 0.3, 66.9 and 32.8 per cent of the samples were found under the acidic, neutral and alkaline categories, respectively. The majority of the samples of all the talukas of the Mehsana district were neutral to alkaline in nature (Table 2). The soil pH of the Sabarkantha district ranged from 6.04 to 9.16. About 76.1 per cent of soil samples had neutral pH whereas 6.2 per cent were acidic range. Similarly, the pH of the surface soil in Patan district ranged from 6.48 to 9.32 and about 0.3, 61.5 and 38.2 per cent of the samples was found in acidic, neutral and alkaline, respectively. These variations in soil pH of the region is attributed to the various soil forming factors, especially types of parent materials (Gruba and Socha 2016), and prevailing climatic parameters such as mean annual precipitation, temperature and evapotranspiration (Zhang *et al*. 2019).

Table 2. Status of Soil pH in soils of Mehsana, Sabarkantha and Patan districts of north Gujarat

pH (1:2.5)							
Talukas	**No. of Samples**	**Min**	**Max**	**Mean**	**Percent Soil Sample**		
					Acidic	**Neutral**	**Alkaline**
Mehsana district							
Bahucharaji	30	7.17	9.09	7.96	0.0	66.7	33.3
Kheralu	30	7.30	8.99	8.17	0.0	60.0	40.0
Kadi	72	6.49	8.76	7.83	1.4	66.7	31.9
Mehsana	72	6.84	8.87	8.03	0.0	68.1	31.9
Satlasna	42	7.17	8.44	8.01	0.0	71.4	28.6
Unja	18	6.50	8.29	7.58	0.0	88.9	11.1
Vadnagar	24	7.60	9.72	8.22	0.0	75.0	25.0
Vijapur	36	7.27	8.34	7.82	0.0	88.9	11.1
Visnagar	36	7.34	9.10	8.47	0.0	30.6	69.4
Overall	360	6.49	9.72	8.01	0.3	66.9	32.8
Sabarkantha district							
Bayad	60	6.59	9.16	8.04	0.0	61.7	38.3
Bhiloda	78	6.16	8.61	7.40	12.8	75.6	11.5
Dhansura	36	6.48	8.83	8.13	2.8	44.4	52.8
Himatnagar	60	7.05	9.14	8.18	0.0	48.3	51.7
Idar	66	6.68	8.45	7.84	0.0	84.8	15.2
Khedbrahma	66	6.09	8.61	7.66	3.0	84.8	12.1
Meghraj	60	6.04	8.34	7.23	18.3	76.7	5.0
Malpur	48	6.09	8.21	7.25	14.6	83.3	2.1
Modasa	48	6.37	8.28	7.61	2.1	91.7	6.3
Prantij	30	6.95	8.33	7.76	0.0	86.7	13.3
Talod	36	7.04	8.45	7.81	0.0	94.4	5.6
Vadali	30	6.45	8.86	7.67	3.3	83.3	13.3
Vijaynagar	42	6.09	8.00	7.06	19.0	81.0	0.0
Overall	660	6.04	9.16	7.66	6.2	76.1	17.7
Patan district							
Chanasma	36	6.48	8.44	7.71	2.8	88.9	8.3
Harij	24	7.27	8.76	8.14	0.0	54.2	45.8
Patan	60	7.26	9.24	8.25	0.0	46.7	53.3
Radhanpur	36	7.85	9.21	8.55	0.0	22.2	77.8
Satalpur	42	7.68	9.32	8.43	0.0	23.8	76.2
Sami	60	7.29	8.57	7.90	0.0	78.3	21.7
Siddhapur	30	6.76	7.86	7.38	0.0	100.0	0.0
Vagdod	24	6.85	7.98	7.29	0.0	100.0	0.0
Overall	312	6.48	9.32	8.01	0.3	61.5	38.2

pH rating: < 6.5 (Acidic), 6.5-8.2 (Neutral), > 8.2 (Alkaline)

Organic carbon (OC)

The status of OC (Table 3) in the Mehsana district varied from 1.0 to 5.8 g kg^{-1} with a mean value of 3.1 g kg^{-1}. Nearly 89.7 per cent samples were low (< 0.50) and the remaining 10.3 per cent samples were under medium (0.5 -0.75) category. The organic carbon status of the Sabarkantha district soil ranged from 1.0 to 7.1 g kg^{-1} with an average value of 4.2 g kg^{-1}. The highest OC deficiency was found in Idar taluka (84.8%) followed by Bayad taluka (80.0%). About 64.7 per cent samples of the district had low organic carbon content. The organic carbon status in soils of Patan district ranged from 0.15 to 0.69 g kg^{-1} with a mean value of 0.40 g kg^{-1}. The deficiency was found highest in Siddhapur taluka (96.7%) followed by Satalpur taluka (90.5 %). The nutrient index values ranged from 1.03 to 1.54 with a mean value of 1.26, in which the overall rating of organic carbon was low in Patan district (Table 3). The major part of the study area had low OC levels because of imbalanced use of fertilizers, low crop residue addition and adoption of excessive tillage practices (Lal 2004 and Shukla *et al*. 2020).

Table 3. Status of organic carbon in soils of Mehsana, Sabarkantha and Patan districts of north Gujarat

OC (g kg^{-1})									
Talukas	**No. of Samples**	**Min**	**Max**	**Mean**	**Percent Soil Sample**			**NI value**	**Fertility class**
					Low	**Medium**	**High**		
Mehsana district									
Bahucharaji	30	1.0	5.5	2.4	96.7	3.3	0.0	1.03	Low
Kheralu	30	1.1	5.3	2.8	83.3	16.7	0.0	1.17	Low
Kadi	72	1.1	5.7	3.0	96.7	3.3	0.0	1.03	Low
Mehsana	72	1.5	5.8	3.5	86.1	13.9	0.0	1.14	Low
Satlasna	42	1.5	5.6	3.5	83.3	16.7	0.0	1.17	Low
Unja	18	2.0	5.5	4.3	61.1	38.9	0.0	1.39	Low
Vadnagar	24	1.4	5.1	3.2	95.8	4.2	0.0	1.04	Low
Vijapur	36	1.0	5.5	3.2	88.9	11.1	0.0	1.11	Low
Visnagar	36	1.0	4.5	2.0	100.0	0.0	0.0	1.00	Low
Overall	360	1.0	5.8	3.1	89.7	10.3	0.0	1.10	Low
Sabarkantha district									
Bayad	60	1.1	5.9	3.9	80.0	20.0	0.0	1.20	Low
Bhiloda	78	1.0	6.0	4.4	53.8	46.2	0.0	1.46	Low
Dhansura	36	1.1	5.8	3.9	69.4	30.6	0.0	1.31	Low
Himatnagar	60	1.1	5.8	3.7	75.0	25.0	0.0	1.25	Low
Idar	66	1.0	7.0	3.1	84.8	15.2	0.0	1.15	Low
Khedbrahma	66	1.2	5.9	3.9	69.7	30.3	0.0	1.30	Low
Meghraj	60	1.3	6.4	4.2	66.7	33.3	0.0	1.33	Low
Malpur	48	1.8	7.1	4.3	70.8	29.2	0.0	1.29	Low
Modasa	48	2.3	7.0	4.8	47.9	52.1	0.0	1.52	Low
Prantij	30	1.7	7.1	4.2	63.3	36.7	0.0	1.37	Low
Talod	36	1.9	7.0	5.0	52.8	47.2	0.0	1.47	Low
Vadali	30	2.1	7.1	5.5	30.0	70.0	0.0	1.70	Medium
Vijaynagar	42	1.9	6.5	4.7	50.0	50.0	0.0	1.50	Low
Overall	660	1.0	7.1	4.2	64.7	35.3	0.0	1.35	Low
Patan district									
Chanasma	36	1.7	6.5	4.0	61.1	38.9	0.0	1.39	Low
Harij	24	2.5	6.9	4.8	45.8	54.2	0.0	1.54	Low
Patan	60	1.5	6.9	4.1	78.3	21.7	0.0	1.22	Low
Radhanpur	36	1.6	6.8	3.9	69.4	30.6	0.0	1.31	Low
Satalpur	42	1.6	6.3	3.5	90.5	9.5	0.0	1.10	Low
Sami	60	2.5	6.8	4.5	66.7	33.3	0.0	1.33	Low
Siddhapur	30	1.5	6.5	2.7	96.7	3.3	0.0	1.03	Low
Vagdod	24	1.6	6.0	3.8	82.6	17.4	0.0	1.17	Low
Overall	312	1.5	6.9	4.0	73.9	26.1	0.0	1.26	Low

OC (%) rating: < 0.50 (Low), 0.50-0.75 (Medium), > 0.75 (High)

$CaCl_2$ extractable S

In Mehsana district, available S content ranged from 3.24 to 61.3 mg kg^{-1} with an overall mean value of 15.6 mg kg^{-1} and 18.1 per cent soil samples were found in deficient in available S. The highest per cent deficiency was observed in Vadnagar taluka (37.5) followed by Bahucharaji (36.7) and Kheralu (30.0) taluka of the Mehsana district. The nutrient index values varied from 1.71 to 2.21 with a mean of 2.01. The overall fertility status for available sulphur was medium in the category (Table 4). Available S content in the Sabarkantha district ranged from 3.90 to 68.5 mg kg^{-1} with an overall mean value of 14.7 mg kg^{-1}. The mean available S status was found low in Meghraj (12.2 mg kg^{-1}) and high in Bayad taluka (17.1 mg kg^{-1}). The highest

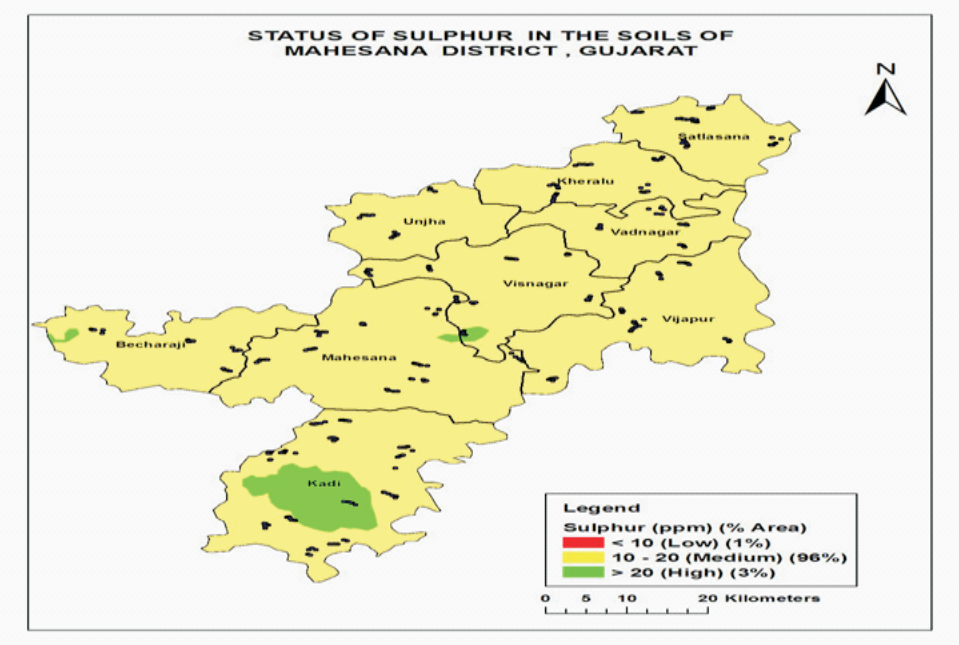

Fig. 2. Status of available S in soils of Mehsana district

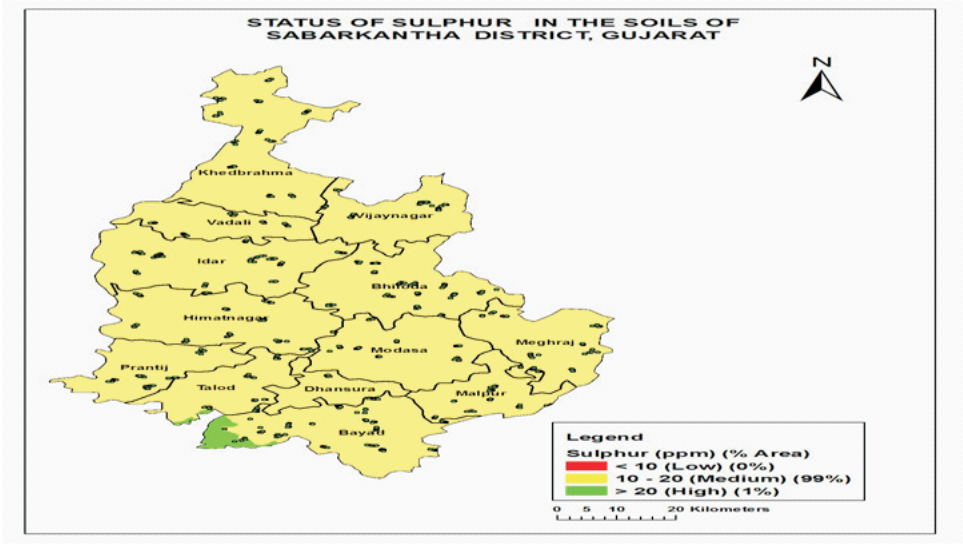

Fig. 3. Status of available S in soils of Sabarkantha district

per cent deficiency was observed in Idar taluka (43.9), and the lowest per cent deficiency was observed in Vadali taluka (10.0). The nutrient index values varied from 1.67 to 2.10 with a mean of 2.09. The overall fertility status for available sulphur was medium (Table 3). Similarly, in Patan district, available S content ranged from 1.7 to 31.9 mg kg^{-1} with mean value of 14.9 mg kg^{-1}. The available sulphur content was found deficient in 16.9% samples, medium in 64.1% and sufficient in 19.0% samples of Patan district. The highest per cent deficiency was observed in Sami taluka (30.0). The nutrient index values varied from 1.80 to 2.31 with a

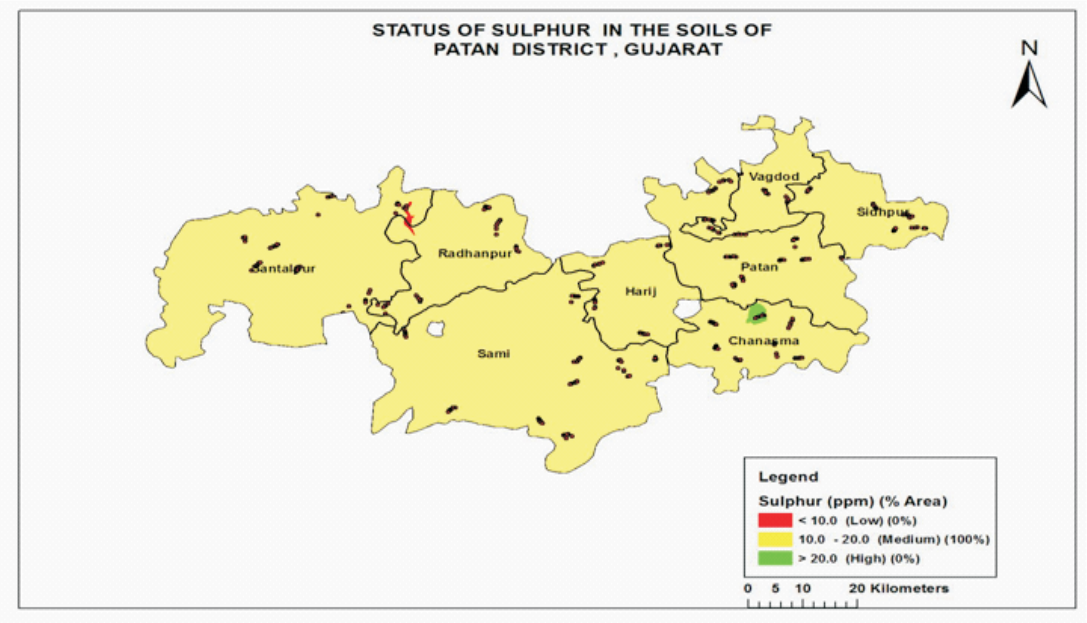

Fig. 4. Status of available S in soils of Patan district

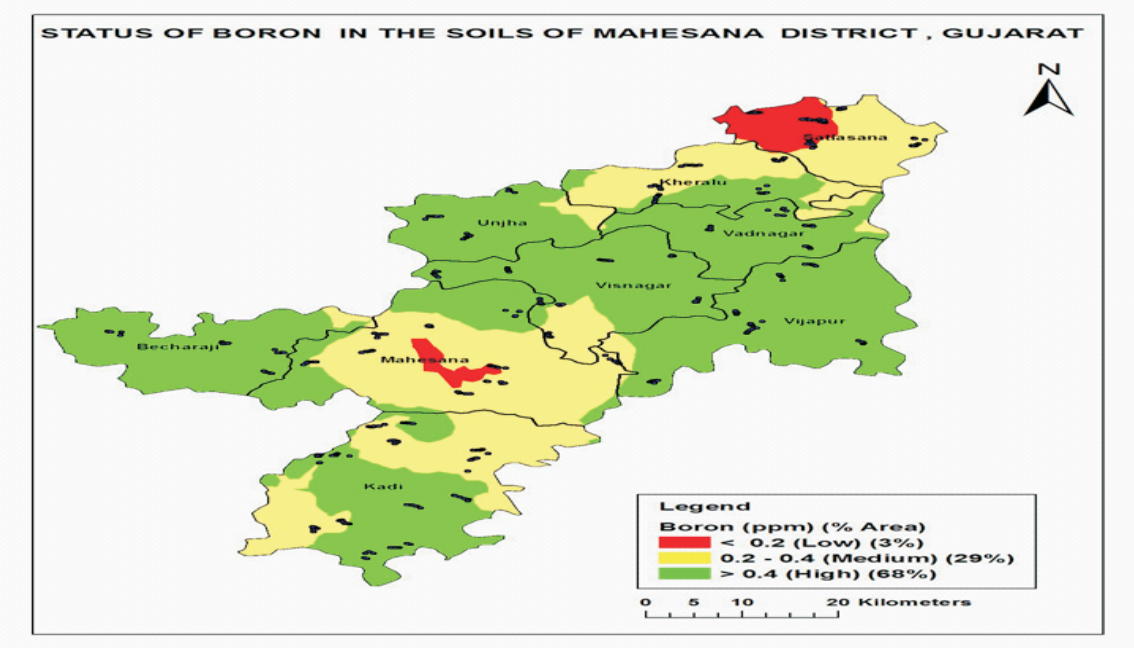

Fig. 5. Status of Hot Water Soluble-B in soils of Mehsana district

mean of 2.02. The overall fertility status for available sulphur was medium (Table 4). The soil fertility map pertaining to S in all three districts are shown in figures 2, 3 and 4. The native supply of S and micronutrients is determined by weathering of the parent material (Anderson 1988). The organic acids released from the decomposition of crop residue as well as by the microbes facilitate the weathering of soil minerals and thus nutrient release. The variations of the available S content in different talukas of all the tree districts might be due to differences in inherent S content in soils, soil properties , soil-crop management practices and inequality between addition and removal of S under different cropping systems (Tandon 2011).

Hot water-soluble – B

Table 4. Status of available sulphurin soils of Mehsana, Sabarkantha and Patan districts of north Gujarat

Available Sulphur (mg kg^{-1})									
Talukas	**No. of Samples**	**Min**	**Max**	**Mean**	**Percent Soil Sample**			**NI value**	**Fertility class**
					Deficient	**Medium**	**Sufficient**		
Mehsana district									
Bahucharaji	30	5.7	40.7	14.5	36.7	43.3	20.0	1.83	Medium
Kheralu	30	6.3	56.5	15.8	30.0	53.3	16.7	1.87	Medium
Kadi	72	9.3	48.6	17.5	6.9	65.3	27.8	2.21	Medium
Mehsana	72	5	30.6	15.2	8.3	75.0	16.7	2.08	Medium
Satlasna	42	7.1	61.3	15.7	14.3	71.4	14.3	2.00	Medium
Unja	18	6.7	46.9	15.7	11.1	77.8	11.1	2.00	Medium
Vadnagar	24	3.6	28.6	12.5	37.5	54.2	8.3	1.71	Medium
Vijapur	36	3.2	27.5	13.2	27.8	58.3	13.9	1.86	Medium
Visnagar	36	5.8	54.7	17.8	19.4	52.8	27.8	2.08	Medium
Overall	360	3.2	61.3	15.6	18.1	63.1	18.9	2.01	Medium
Sabarkantha district									
Bayad	60	3.9	52.1	17.1	16.7	56.7	26.7	2.10	Medium
Bhiloda	78	5.9	68.5	16	21.8	59.0	19.2	1.97	Medium
Dhansura	36	7.5	36	13.5	27.8	63.9	8.3	1.81	Medium
Himatnagar	60	6.3	58.8	16.4	16.7	61.7	21.7	2.05	Medium
Idar	66	4.3	53.3	12.7	43.9	45.5	10.6	1.67	Medium
Khedbrahma	66	5.4	34.4	12.7	40.9	47.0	12.1	1.71	Medium
Meghraj	60	6.6	35.3	12.2	38.3	55.0	6.7	1.68	Medium
Malpur	48	5.8	30.5	13.6	22.9	62.5	14.6	1.92	Medium
Modasa	48	7.2	49.1	15.3	14.6	70.8	14.6	2.00	Medium
Prantij	30	8.4	28.9	14.4	26.7	56.7	16.7	1.90	Medium
Talod	36	6.2	46.5	16.9	22.2	50.0	27.8	2.06	Medium
Vadali	30	5.1	29.3	15.2	10.0	73.3	16.7	2.07	Medium
Vijaynagar	42	5.9	30.8	16	11.9	69.0	19.0	2.07	Medium
Overall	660	3.9	68.5	14.7	25.5	58.2	16.4	1.91	Medium
Patan district									
Chanasma	36	9.3	29.1	17.9	11.1	47.2	41.7	2.31	Medium
Harij	24	3.2	31	15.6	16.7	58.3	25.0	2.08	Medium
Patan	60	9.9	31.9	16.1	5.0	73.3	21.7	2.17	Medium
Radhanpur	36	1.8	27.5	13.4	16.7	72.2	11.1	1.94	Medium
Satalpur	42	1.7	26.9	12.8	23.8	66.7	9.5	1.86	Medium
Sami	60	7.4	29.5	13.6	30.0	60.0	10.0	1.80	Medium
Siddhapur	30	8.6	31.8	15.2	16.7	70.0	13.3	1.97	Medium
Vagdod	24	5.5	30.6	15.7	13.0	56.5	30.4	2.17	Medium
Overall	312	1.7	31.9	14.9	16.9	64.1	19.0	2.02	Medium

Available Sulphur (mg kg^{-1}) rating: < 10 (Deficient), 10-20 (Medium), > 20 (Sufficient)

The HWS-B in the soils varied from 0.06 to 2.49 mg kg^{-1} with a mean of 0.44 mg kg^{-1} in Mehsana district (Table 5). The percentage of samples under deficient, medium and sufficient category for HWS-B were 29.4, 29.2 and 41.4, respectively. The highest deficiency (52.4%) of B was found in Satlasna Taluka of the district. The nutrient index values varied from 1.55 to 2.70, with a mean of 2.12 in Mehsana district. In Sabarkantha district, HWS-B availability in the soils varied from 0.10 to 3.12 mg kg^{-1} with a mean of 0.45 mg kg^{-1}. The percentage of samples under deficient, medium and sufficient category for HWS-B were 17.9, 38.8 and 43.3 per cent in deficient, medium and sufficient category, respectively. In Patan district, the HWS-B availability in the soils varied from 0.08 to 1.93 mg kg^{-1}

Table 5. Status of HWS-B in soils of Mehsana, Sabarkantha and Patan districts of north Gujarat

Hot Water Soluble-B (mg kg^{-1})									
Talukas	**No. of Samples**	**Min**	**Max**	**Mean**	**Percent Soil Sample**			**NI value**	**Fertility class**
					Deficient	**Medium**	**Sufficient**		
Mehsana district									
Bahucharaji	30	0.18	2.49	0.69	6.7	16.7	76.7	2.70	High
Kheralu	30	0.10	1.82	0.31	36.7	46.7	16.7	1.80	Medium
Kadi	72	0.06	1.39	0.41	29.2	36.1	34.7	2.06	Medium
Mehsana	72	0.06	1.35	0.35	37.5	26.4	36.1	1.99	Medium
Satlasna	42	0.06	0.63	0.20	52.4	40.5	7.1	1.55	Low
Unja	18	0.12	2.39	0.75	11.1	27.8	61.1	2.50	High
Vadnagar	24	0.06	2.15	0.72	29.2	4.2	66.7	2.38	High
Vijapur	36	0.07	1.25	0.47	19.4	27.8	52.8	2.33	High
Visnagar	36	0.09	1.24	0.49	19.4	22.2	58.3	2.39	Medium
Overall	360	0.06	2.49	0.44	29.4	29.2	41.4	2.12	Medium
Sabarkantha district									
Bayad	60	0.10	1.04	0.31	36.7	40.0	23.3	1.87	Medium
Bhiloda	78	0.10	1.18	0.56	7.7	20.5	71.8	2.64	High
Dhansura	36	0.12	0.73	0.40	11.1	50.0	38.9	2.28	Medium
Himatnagar	60	0.10	1.59	0.49	23.3	28.3	48.3	2.25	Medium
Idar	66	0.10	0.82	0.33	27.3	45.5	27.3	2.00	Medium
Khedbrahma	66	0.10	1.03	0.32	25.8	50.0	24.2	1.98	Medium
Meghraj	60	0.17	3.12	0.41	6.7	71.7	21.7	2.15	Medium
Malpur	48	0.10	1.65	0.37	31.3	39.6	29.2	1.98	Medium
Modasa	48	0.23	1.51	0.66	0.0	22.9	77.1	2.77	High
Prantij	30	0.18	1.45	0.51	3.3	46.7	50.0	2.47	High
Talod	36	0.11	1.89	0.73	2.8	22.2	75.0	2.72	High
Vadali	30	0.18	1.50	0.53	3.3	26.7	70.0	2.67	High
Vijaynagar	42	0.11	1.62	0.37	35.7	35.7	28.6	1.93	Medium
Overall	660	0.10	3.12	0.45	17.9	38.8	43.3	2.25	Medium
Patan district									
Chanasma	36	0.10	0.79	0.37	19.4	41.7	38.9	2.19	Medium
Harij	24	0.11	1.39	0.41	25.0	37.5	37.5	2.13	Medium
Patan	60	0.08	0.75	0.32	33.3	33.3	33.3	2.00	Medium
Radhanpur	36	0.10	0.88	0.43	19.4	27.8	52.8	2.33	Medium
Satalpur	42	0.17	1.88	0.65	4.8	33.3	61.9	2.57	High
Sami	60	0.10	1.93	0.47	20.0	31.7	48.3	2.28	Medium
Siddhapur	30	0.10	1.62	0.45	10.0	46.7	43.3	2.33	Medium
Vagdod	24	0.12	0.90	0.42	8.7	47.8	43.5	2.35	High
Overall	312	0.08	1.93	0.44	19.2	35.9	44.8	2.26	Medium

HWS-B (mg kg^{-1}) rating: < 0.2 (Deficient), 0.2-0.4 (Medium), > 0.4 (Sufficient)

districts are depicted in figs 5, 6 and 7.

with a mean of 0.44 mg kg^{-1}. The lowest HWS-B availability (mean value of 0.32 mg kg^{-1}) was observed in Patan taluka whereas the highest avaialability was found in Satalpur taluka (0.65 mg kg^{-1}). The fertility maps of B in all three districts are districts are depicted in figs. 5, 6 and 7. The variability in B content in different parts of the districts are mainly due to the cultivation of different crops, adopting different soil-crop management practices, and non-addition of B containing fertilizers (Shukla *et al*. 2020).

Conclusion

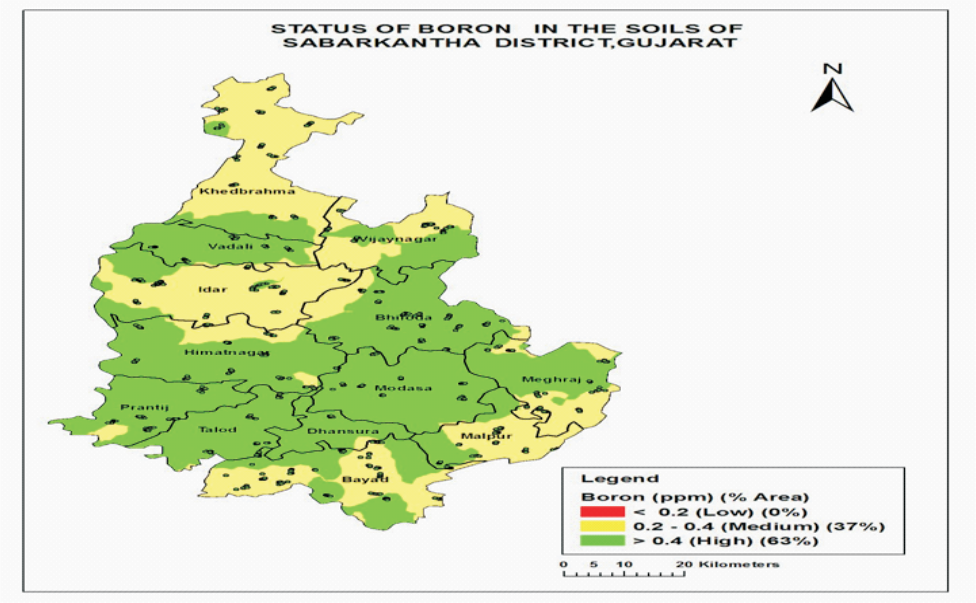

Fig. 6. Status of Hot Water Soluble-B in soils of Sabarkantha district

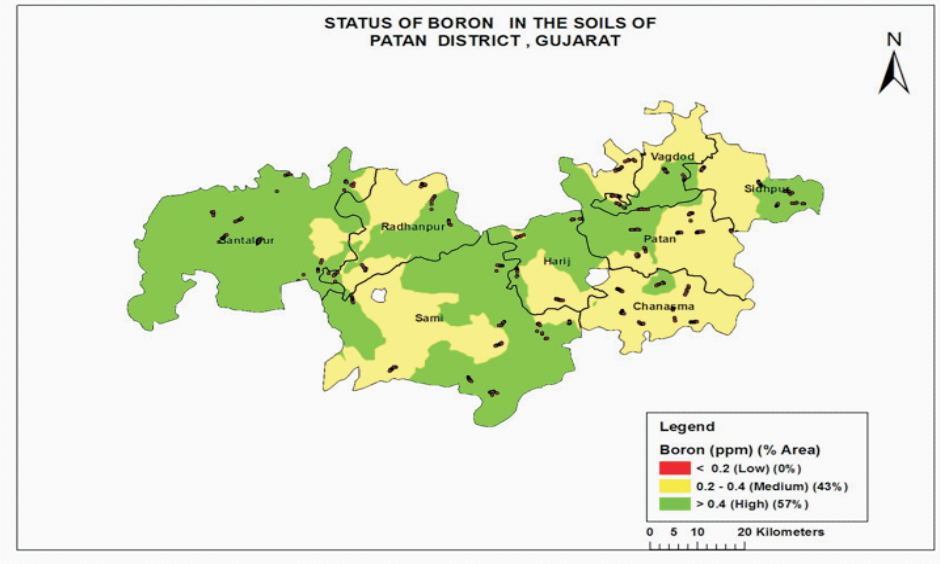

Fig. 7. Status of Hot Water Soluble-B in soils of Patan district

The study indicated that S and B deficiencies in the districts of Mehsana, Patan and Sabarkantha was to the tune of 22 and 21 per cent, which is a significant cause of concern. There is a need to apply S and B fertilizers based on soil test values to enhance crops productivity, since bajara, wheat, cotton, castor, maize, potato and rice crops are widely grown in north Gujarat.

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