Agropedology 2017, 27 (01) 56 - 62

Spatial Variability of Major and Micro Nutrients in Soils of Bhandara District, Maharashtra

R. N. Katkar*, S. R. Lakhe, V. K. Kharche, P. N. Magare and G. S. Laharia

Department of Soil Science and Agricultural Chemistry,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444104, India

Abstract: The georeferenced surface soil samples from Bhandara district of Maharashtra were collected using Global Positioning System (GPS) to study the variability in the availability of N, P, K, S, Zn, Fe, Cu, Mn and B. The fertility maps were prepared using Geographical Information System for each nutrient. The results revealed that soil reaction is acidic to slightly alkaline (4.16 to 8.35), whereas organic carbon content varied from very low to very high (0.65 to 1.43 g kg^{-1}). The available nitrogen ranged from 73.8 to 273.9 kg ha^{-1} and available phosphorus varied from 1.03 to 63.0 kg ha^{-1} indicating deficiency in 89.2 per cent samples. The available potassium and sulphur ranged from 112.0 to 795.2 kg $ha^{-1}$and 7.94 to 36.49 mg kg^{-1} respectively. The DTPA-Zn ranged from 0.10 – 2.60 mg kg^{-1} showing 58.01 per cent samples deficient while DTPA-Fe varied from 1.56 to 197.36 mg kg^{-1}. DTPA-Mn and Cu were found to be sufficient. The nutrient indices of nitrogen (1.00) and phosphorus (1.13) were found low, medium for sulphur (2.08), high for potassium (2.75), low for zinc (1.44), medium for boron (1.82) and high for iron (2.63), copper (2.96) and manganese (2.91).

Key words: *Spatial variability, GPS, GIS, fertility maps*

Introduction

Global Positioning System (GPS) which helps in collecting a systematic set of geo-referenced soil samples and generating the spatial data about the distribution of nutrients through Geographical Information System (GIS).The soil factors *viz.,* texture, pH, organic matter content, calcium carbonate content, type of clay minerals and interactions among the nutrients markedly regulate the availability of nutrients in soils (Malewar 2005). Imbalanced and inadequate use of fertilizers coupled with poor use efficiency of other inputs led to decline in the response efficiency of chemical fertilizer nutrients under intensive agriculture in recent years.

The micronutrients are important for maintaining soil health and increasing the use efficiency of major nutrients and ultimately the crop productivity. The deficiency of micronutrients has become major constraint in sustainable crop productivity of soils and hence there is need to know the spatial variability of nutrients of the soil. Keeping this in view, the present investigation was undertaken to assess the status of major and micronutrients in soils, their relationships and to identify and delineate the deficient zone in Bhandara district of Maharashtra.

Material and Methods

Bhandara district is located between 20° 39' to 21° 38' North latitude and 70° 27' to 80° 42' East longitude with total geographical area of 3, 42,000 ha with a mean annual rainfall of 1298 mm. Apart from igneous and sedimentary rocks, alluvium occurs along the river Vainganga.

The georeferenced surface soil samples (0-20 cm) were collected from77 villages in seven tehsils of Bhandara district during 2010-11. The sampling villages were selected using stratified random method. Six farmers from each village were selected based on land holdings. Two soil samples were collected from each

*Corresponding author (Email : rajkatkar5@gmail.com)

fields of small (less than 1 ha), medium (1-3 ha) and large (above 3 ha) land holding group and thus there were four hundred sixty two geo-referenced soil samples. The soil samples were processed and analyzed for pH and EC in soil: water suspensions (1:2.5 w/v) as described by Jackson (1973). Organic carbon was determined by wet oxidation method as described by Walkley and Black (Nelson and Sommers 1982) and free $CaCO_3$ was determined by rapid titration method (Piper 1966).

The available N was estimated by alkaline permanganate method (Subbiah and Asija 1956), available P by Bray's method (Bray and Kurtz 1945), available K by ammonium acetate extraction method (Jackson 1967) and the available S was estimated by turbid metric method (Chesnin and Yien 1951).The micro nutrient cations in soils were extracted with 0.005*M* diethylene triaminepenta acetic acid (DTPA) and contents were estimated using Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978). Available boron was determined by 0.01*M* $CaCl_2$extract with Azo-methine method (Berger and Troug 1939). The nutrient indices were calculated by using the formula given by Parker *et al.* (1951) and categorized into low (<1.66), medium (1.66 – 2.33) and high (> 2.33) as outlined by Ramamurthy and Bajaj (1969). The major and micronutrients were categorized as low, medium and high which is followed in Maharashtra state (Table 1).

$$\text{Nutrient index} = \frac{\%\ \text{samples low} \times 1 + \%\ \text{samples medium} \times 2 + \%\ \text{samples high} \times 3}{100}$$

Results and Discussion

Soil properties

The pH of soils in ranged from 4.16 – 8.35 (Table 2) being highest in Bhandara tehsil (8.35) and lowest in Lakhandur tehsil (4.16). All the soils were non-saline (0.01 to 0.86 dS m^{-1}). The organic carbon content in soils ranged from 0.65 to 1.43g kg^{-1}. Organic carbon deficiency was recorded in 27.9 per cent soil samples. The calcium carbonate content in soils of the district varied from 0.25 to 6.12 per cent.

Major nutrients status

The available nitrogen was noticed in the range of 73.8 to 273.9kg ha^{-1}, which showed widespread deficiency (Fig 1). The deficiency of available nitrogen might be due to less addition of organic manures and higher N-uptake by high yielding varieties of different crops. The available P varied from very low to very high (1.03-63.0 kg ha^{-1}) indicating 89.2 per cent deficiency in the tehsils. The deficiency of available P is ascribed to its fixation with aluminum, iron or free $CaCO_3$.The available K ranged from 112.0 to 795.2 kg ha^{-1} and 3 per cent samples were deficient while 18 per cent samples were found medium. This could be attributed to intense weathering, release of labile K from organic residues, application of K fertilizers and upward

Table 1. Categorization of soil parameters and nutrients

Sr. No.	Parameters	Low	Medium	High
1	pH (1:2.5)	<6.5(Acidic)	6.5-7.5(Neutral)	>7.5(Alkaline)
2	EC (dS m^{-1})	<1.0	1-2	>2.0
3	O.C. (g kg^{-1})	<4.0	4-8	>8.0
4	$CaCO_3$ (%)	<3.0	3-8	>8.0
5	N (kg ha^{-1})	<280	280-560	>560
6	P (kg ha^{-1})	<14	14-28	>28
7	K (kg ha^{-1})	<150	150-250	>250
8	S (mg kg^{-1})	<10.0	10-20	>20.0
9	Zn (mg kg^{-1})	<0.60	0.6-1.80	>1.80
10	Fe (mg kg^{-1})	<4.50	4.50-18.0	>18.0
11	Cu (mg kg^{-1})	<0.20	0.20-0.80	>0.80
12	Mn (mg kg^{-1})	<2.0	2.0-8.0	>8.0
13	B (mg kg^{-1})	<0.50	0.50-1.0	>1.0
14	Mo (mg kg^{-1})	<0.10	0.10-0.40	>0.40

Table 2. Macronutrients status of Bhandara district

Sr. No.	Name of tehsil	pH (1:2.5) Range	EC ($dS\ m^{-1}$) Range	$CaCO_3$ (%) Range	Organic carbon ($g\ kg^{-1}$) Range	N Range	N PSD	P Range	P PSD	K Range	K PSD	S Range	S PSD
						Kg ha^{-1}							
1.	Tumsar	4.97-7.98	0.031 - 0.678	1.50-6.12	0.65-14.39	94.8-273.9	10	1.08-26.63	96.15	112.0-772.8	5.13	8.68-27.64	3.84
2.	Mohadi	5.28-8.19	0.041 - 0.501	0.37-5.87	1.04-9.27	84.3-252.9	10	1.25-56.05	90.91	112.0-784.0	1.52	8.42-34.49	10.60
3.	Bhandara	5.06-8.35	0.032 - 0.859	1.25-5.62	1.95-12.0	94.8-242.3	10	1.17-63.0	85.71	145.6-784.0	2.38	8.74-33.93	3.57
4.	Sakoli	4.55-7.48	0.043 - 0.342	0.62-6.00	1.04-11.29	115.9-231.8	10	1.07-23.76	94.45	112.0-627.2	9.26	10.14-19.25	00
5.	Lakhani	4.32-7.53	0.010 - 0.18	0.62-6.00	1.63-9.65	94.8-221.3	10	1.14-57.28	87.04	112.0-795.2	3.70	10.05-35.06	00
6.	Pawani	4.66-8.18	0.051 - 0.283	2.00-5.87	1.89-8.89	73.8-221.3	10	1.03-61.20	83.34	179.2-705.6	00	8.90-19.02	5.13
7.	Lakhandur	4.16-7.83	0.031 - 0.298	0.25-5.87	1.65-7.95	84.3-221.3	10	1.08-39.57	87.50	179.2-761.6	00	7.94-20.48	16.67
	Bhandaradistrict	4.16-8.35	0.01 - 0.859	0.25-6.12	0.65-14.39	73.8-273.9	10	1.03-63.0	89.18	112.0-795.2	3.03	7.94-36.49	5.41

PSD – Percent sampl edeficient

translocation of K from lower depths along with capillary rise of ground water (Sharma and Anil Kumar 2003). The available sulphur varied from low to very high (7.94 to 36.49 g kg^{-1}) showing deficiency in 86.6 per cent samples (Table 3). The intensive cultivation of crops and application of fertilizers devoid of sulphur might be depleting the sulphur in soil.

Micronutriments statuts

The DTPA-Zn in soils of Bhandara district ranged from 0.10 to 2.60 mg kg^{-1} (Table 4) indicating deficiency in 58.0 per cent soil samples.The highest deficiency of zinc was observed in Mohadi tehsil followed by Tumsar, Pawani and Bhandara. The availability of micronutrient cations is generally low in alkaline soils and crops grown on these soils suffer from hidden hunger (Malewar 2005).

The major crops grown in these tehsils are paddy, pigeon pea, green gram, chickpea *etc*., and their intensive cultivation might have mined the zinc along with N, P and K over a long period. All the tehsils indicated wide spread of zinc deficiency in Bhandara district. The deficiency of nutrients creates imbalance in soils which results into nutritional stress in plants (Malewar 2005).

The wide variation was noticed in DTPA-Fe (1.56 to 197.36mg kg^{-1}) in Bhandara district. The per cent deficiency of iron was 4.3, while 27.9 per cent samples under medium category (Table 4) indicating that the soils are becoming deficient in iron followed by zinc Patil *et al.* (2004) reported 40.0 and 34.7 per cent soils deficient in zinc and iron respectively in Vidarbha.

The DTPA-Cu in the soils of Bhandara district ranged from 0.21 to 7.63 mg kg^{-1} (Table 4). Patil and Sonar (1994) reported that, in swell-shrink soils of Maharashtra, available Cu was in range of 0.58 to 1.7 mg kg^{-1}. The majority of soils in Bhandara district were found sufficient in Cu content.

The DTPA-Mn status of soils ranged from 2.20 to 180.9 mg kg^{-1} **(Table 4)**. Gajbhe *et al*. (1976) reported that available Mn content in surface soils of Marathwada ranged from 13.3 to 65.20 mg kg^{-1}. The deficiencies of Mn and Cu in the soils of Bhandara district were not observed. The $CaCl_2$-B in soils of all the tehsils ranged from 0.24 to 1.07 mg kg^{-1}.The boron deficiency was observed in 16.32 per cent samples while 82.99 per cent samples were noticed in medium category. The

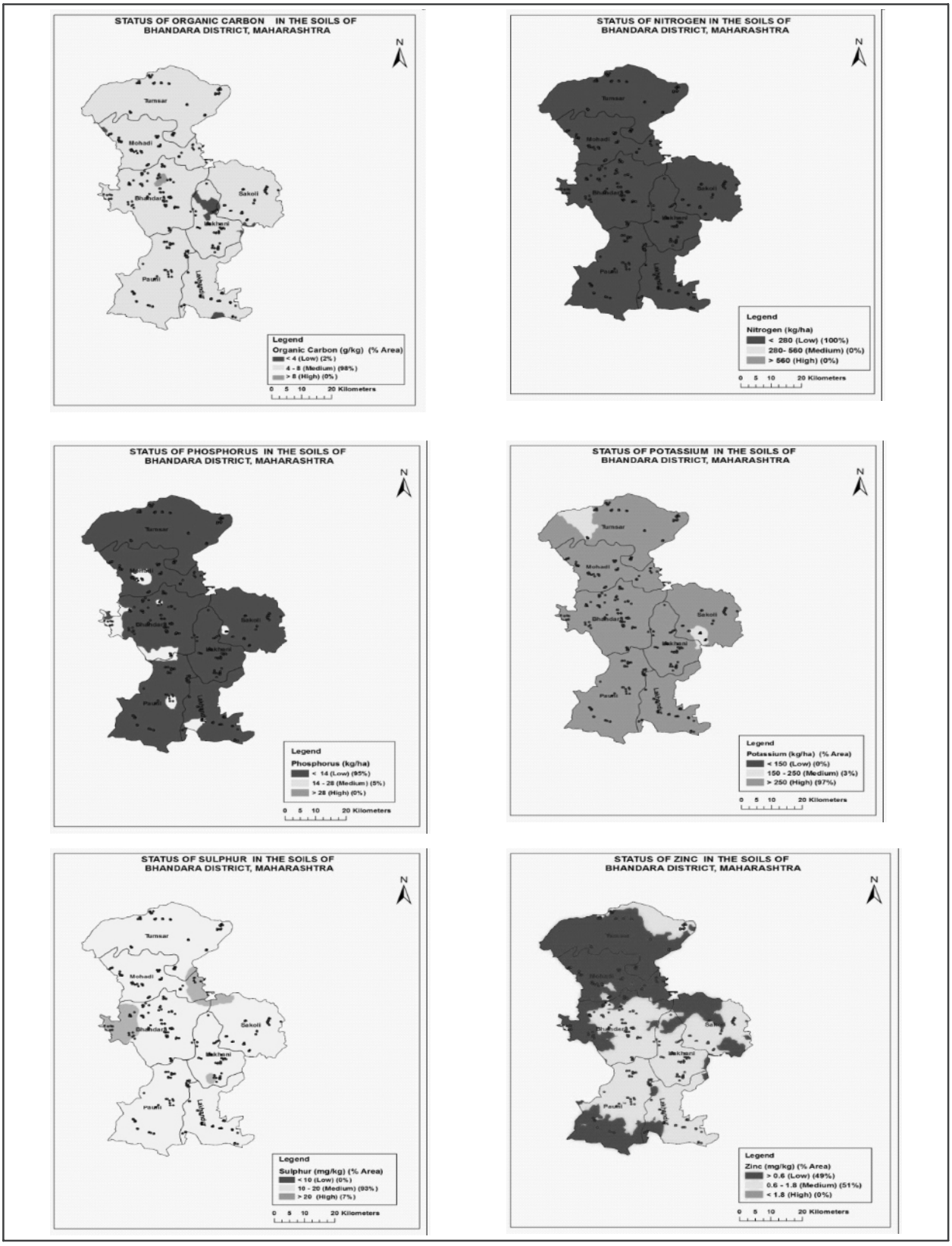

Fig 1. Fertility maps of nutrients in Bhandara district

Table 3. Extractable micronutrients status in soil

Sr. No.	Tehsils	DTPA-Zn		DTPA-Fe		DTPA-Cu		DTPA-Mn		$CaCl_2$-B	
		(mg kg^{-1})									
		Range	PSD*	Range	PSD*	Range	PSD*	Range	PSD*	Range	PSD
1.	Tumsar	0.112-2.60	66.67	5.14-185.03	00	1.10-6.94	0	3.98-180.9	0	0.32-0.75	23.80
2.	Mohadi	0.11-1.22	77.28	1.56-77.5	13.6	0.53-3.95	0	3.54-118.56	0	0.24-0.66	23.80
3.	Bhandra	0.12-1.46	58.34	2.04-96.06	3.57	0.63-7.63	0	5.28-162.30	0	0.48-0.68	19.0
4.	Sakoli	0.10-1.87	44.44	3.96-182.56	1.85	0.76-3.47	0	10.8-124.48	0	0.47-0.67	14.28
5.	Lakhani	0.16-1.88	46.29	2.84-197.36	1.85	0.74-6.39	0	5.64-111.36	0	0.45-0.65	14.28
6.	Pawani	0.18-1.91	62.83	2.08-98.92	2.56	0.49-6.73	0	2.20-130.48	0	0.55-1.07	9.52
7.	Lakhandur	0.33-1.58	37.50	2.27-165.60	8.33	0.21-7.77	0	3.10-134.96	0	0.45-0.74	9.52
	Bhandara district	0.112-2.60	58.01	1.56-197.36	4.33	0.21-7.63	0	2.20-180.9	0	0.24-1.07	16.32

* Per cent sample deficient

deficiency was noticed in Mohadi, Tumsar and Bhandara tehsils followed by Sakoli and Lakhani tehsils.

Nutrient indices

The nutrient indices ranged from 1.23 - 1.62 for Zn, 2.17 – 2.87 for Fe, 2.34 – 2.98 for Cu, 1.62 – 2.98 for Mn and 1.76 - 1.90 for B. Notably low fertility rating was recorded for Zn in majority of the tehsils, high for Cu and Mn, medium to high for Fe and medium for $CaCl_2$- B. The areas where the nutrients are medium may show deficiency in near future if INM practices were not implemented based on soil testing for intensive cultivation of different crops (Malewar 2005).

Table 4. Status of nutrients and nutrient indices in Bhandara district

Nutrients	Per cent samples			Nutrient Index
	Low	Medium	High	
N	100.0	00	00	1.00
P	89.18	6.49	4.33	1.13
K	3.03	18.40	78.57	2.75
S	5.41	81.17	13.42	2.08
Zn	58.01	40.91	1.08	1.44
Fe	4.33	27.92	67.75	2.63
Cu	—	3.68	96.32	2.96
Mn	—	8.66	91.34	2.91
B	16.32	82.99	0.67	1.82

Relationship of nutrients with soil properties

The DTPA-Zn showed negative relationship with soil pH (r = -0.162*) and calcium carbonate (r=-0.156**). An increase in pH normally affects the availability of zinc in soils adversely on. Diwale and Chavan (1999) found significant positive correlation of DTPA-Zn with organic carbon in soil of south Konkan. The correlation of iron with organic carbon (r = -0.070) was negatively non-significant and significantly correlated with pH (r = - 0.455**). Devdas and Chandrakar (2014) observed significant negative correlation of available Fe with pH in Vertisols of Navagarh block under Janjgir district in Chattisgarh. Jayashree Deka and Sarma (2012) also reported that concentration of Fe appeared to be negatively correlated with organic matter. Significant

negative relationship of available iron with pH and $CaCO_3$ content of soil were also reported by (Maji *et al.* 1993). Significant positive correlation of available Cu (r=0.061*) was observed with $CaCO_3$ (Reshma *et al.* 2016). Available manganese showed negative significant relation with pH of the soil. Reshma *et al.* (2016) reported significant negative correlation (r = -0.084**) of Mn with soil pH.

Conclusions

GPS-GIS technique has been found useful for systematic mapping of spatial variability of macro and micronutrient for nutrients management to increase the productivity of crops. Among the major nutrients, nitrogen (100%) and phosphorus (89%) were found deficient. The micronutrients *viz.,* zinc (58%), iron (4%) and boron (16%) showed deficiency. The information on current status of spatial variability micronutrients in soils of Bhandara district will be helpful to suggest the efficient ways and methods of balanced nutrient application for enhancing the yields by using recommended quantities of organic manures and inorganic fertilizers in the areas of major and micro-nutrients deficiency.

References

Berger K.C. and Truog E. (1939). Boron determination in soils and plants. *Industrial Engineering Chemistry Analytical Edition* **11,** 540-545.

Bray R.H. and Kurtz L.T. (1945). Determination of total, organic and available forms of phosphorus in soil. *Soil Science* **59**, 39-45

Chesnin L. and Yein C.H. (1951).Turbidimetric determination of available sulphates. *Soil Science Society of America Proceedings* **15**, 149-157.

Devdas Deepika and Chandrakar Kunal (2014). Study on correlation between status of pH, organic carbon and available Fe in black soil of Navagarh block under Janjgir District in Chhattisgarh. *Journal of Progressive Agriculture***5,** 28-30.

Diwale S.R. and Chavan K.N. 1999. Distribution of zinc in lateritic soils of Konkan. *Journal of Maharashtra Agricultural Univ*ersities **24,** 9-13.

Gajbhe M.V., M.G. Lande and S.B. Varade (1976). Soils of Marathwada. *Journal of Maharashtra Agricultural Universities* **1,** 55-59.

Jackson M. L. (1967). *Soil Chemical Analysis* Prentice Hall of India, Pvt. Ltd New Delhi.

Jackson M. L. (1973). *Soil Chemical Analysis* (Eds.) Prentice Hall of India, Pvt. Ltd New Delhi.

Jayashree Deka and Sarma H. P. (2012). Heavy metal contamination in soil in an industrial zone and its relation with some soil properties. *Archives of Applied Science Research* **4,** 831-836

Kumar R., Sarkar A. S., Singh K. P., Agarwal B. K. and Karmakar S. (2009). Appraisal of available nutrient status in Santhal Paraganas region of Jharkhand. *Journal of the Indian Society of Soil Science***57,** 366-369

Lindsay W. L. and Norvell W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal***42**, 421-428.

Maji A.K., Chatterji S. and Bandyopadhyay B.K. (1993). Available iron, manganese, zinc and copper in coastal soils of sundarbans West Bengal in relation to soil characteristics. *Journal of the Indian Society of Soil Science* **41,** 468-471.

Malewar G. U., (2005). Micronutrient stresses in soils and crops: Serious sickness and clinical approaches for sustainable agriculture. *Journal of the Indian Society of Soil Science* **53,** 484-499.

Nelson D. W. and Sommers L. E. (1982). In *Methods of Soil Analysis*, Part II, Chemical and Microbiological Methods (Page, A. L., R. H. Miller and D. R. Keeney, Eds. Agronomy Monograph No. 9, 2nd edition) *American Society of Agronomy and Soil Science Society of America,* Madison, Wisconsin, USA : 570-572.

Parker F. W., Nelson W. L, Winters E. and Miles I. F. (1951). The broad interpretation and application of soil test information. *Agronomy Journal* **43,** 105-112.

Patil D. B., Bharambe P. R., Deshmukh P. W., Rane P. V. and Guldekar S. V.(2004). Micronutrient status

in soils of Vidharba. *Technical Bulletin* Dr. PDKV, Akola.

Patil J. D. and Kharche V. K. (2001). Crop response to micronutrients in soils of western Maharashtra - An overview. *Journal of Maharashtra Agricultural Universities* **26,** 127-129.

Patil Y. M. and Sonar K. R. (1994). Status of major and micronutrients in swell-shrink soils of Maharashtra. *Journal of Maharashtra Agricultural Univ*ersities **19,** 169-172

Piper C. S. (1966). *Soil and Plant Analysis,* Hans Publicatiobn Bombay. Asian Ed. 368-374.

Ramamurthy B. and Baja J. C. (1969). Available N, P and K status of Indian soils Fertiliser News, **14,** 24-26

Reshma M. R., Duraisami V. P., Muthumanickam D., Soniya Purma and Jayasoorian N. (2016). Relation between soil properties and available micronutrients in soil. *International Journal of Agricultural Science and Research* **6, 247**-252.

Sakal R. (2001). Efficient management of micronutrient for sustainable crop production. *Journal of the Indian Society of Soil Science,* **49, 593**-608.

Sharma V. K. and Anil Kumar (2003). Characterization and classification of the soil of upper Maul Khad catchment in wet temperate zone of Himachal Pradesh. *Agropedology* **13**, 39-49.

Singh M. V. (2003). Issues and challenges in promoting safe use of micronutrients in agriculture during new millennium: Interface on micronutrients, MCEAR, Pune.

Subbiah B. V. and Asija G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science* **25**, 258 - 260.

Zende G. K. (1987). Invited paper in proceedings on micronutrient stress in crop plants, MPKV, Rahuri

Received : April, 2017 Accepted : October, 2017