Journal of the Indian Society of Soil Science, Vol. 69, No. 1, pp 14-20 (2021)
DOI: 10.5958/0974-0228.2021.00015.3

Identification of Soil Fertility Constraints in Boranakunte-1 Micro-Watershed, Tumkur District, Karnataka

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Land resource inventory of Boranakunte-1 micro-watershed (939 ha) representing central dry zone (Zone-4) of Tumkur district, Karnataka was carried out using geospatial techniques. Totally 140 surface soil samples at 250 m^2 grid were collected, characterized for chemical and fertility properties and soil fertility maps were prepared using geographic information system (GIS). The results revealed that the soils were moderately alkaline (pH 8.29±0.47) with low total salt content (EC 0.15±0.10 dS m^{-1}) and low to medium in organic carbon (OC) (0.50±0.20%) status. The available nitrogen (N), phosphorus (P) and potassium (K) contents were 238.9±48.8, 31.6±13.3 and 330.8±109.2 kg ha^{-1}, respectively and the available sulphur (S) was 17.36±9.74 mg kg^{-1}. The exchangeable calcium (Ca) and magnesium (Mg) were 21.62±6.32 and 10.82±3.35 cmol(p^+)kg^{-1}, respectively. The DTPA extractable iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) contents were 2.91±0.80, 0.90±0.32, 2.95±1.86 and 0.46±0.20 mg kg^{-1}, respectively. The hot water extractable boron (B) content was 0.60±0.25 mg kg^{-1}. Soil pH, OC, available N, P, Zn and B were found important soil fertility constraints for crop production in the micro-watershed. Thus, proper nutrient management along with correction of soil reaction and soil conservation measures needs to be done in order to enhance productivity.

Key words: Soil fertility constraints, geographic information system, micro-watershed

An intimate knowledge regarding kinds of soil and their spatial distribution is a prerequisite in developing rational land use plan for agriculture, forestry, irrigation, drainage, *etc*. Soil resource inventory through soil survey provides an insight on potentialities and limitations of a soil for its effective utilization. Accurate and scientific inventory of different soils, and their distribution helps to predict production potentials based on different soil characteristics namely, texture, depth, structure, stoniness, drainage, acidity, salinity, *etc.*

Soil fertility is one of the important factors that control crop yields. Soil characterization of an area in relation to their soil fertility status is important for sustainable agricultural production. Introduction of high yielding varieties in Indian agriculture encouraged the farmers to apply nutrients through fertilizers. However, production response efficiency to fertilizer nutrients declined significantly over the last few decades (Yadav and Meena 2009). Imbalanced and inadequate fertilizer use without micronutrients can affect crop productivity and soil health (Bangre *et al*. 2020). Nutrient availability is largely influenced by pH, soil texture (Nagaraja and Srinivasamurthy 2009) and soil organic matter (Saji *et al*. 2006). Hence, preparing soil resource inventory periodically is essential for better utilization of soil and maintenance of its health.

A number of studies on soil survey were carried out by various workers in India in different regions using aerial photographs. However, use of satellite remote sensing for soil survey and mapping received appreciation during early 1980's in India, and based on the potential of remote sensing techniques, it was decided to map all the States and Union Territories of India on 1:250,000 scale following a multiphase

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approach consisting of image interpretation, field survey, soil analysis, classification, cartography and printing (Velayutham 1999). The use of digital image processing for soil survey and mapping was initiated with the establishment of National Remote Sensing Agency and Regional Remote Sensing Service Centers.

Knowledge of spatial variability in soil fertility is important for site specific nutrient management. A study was conducted with the objective to prepare soil fertility maps using geospatial techniques. In this study, spatial variability in properties that influence soil fertility such as soil organic carbon (OC), available nitrogen (N), phosphorus (P), potassium (K), secondary and micronutrients in surface soils from the farmers field of Boranakunte-1 micro-watershed, Karnataka was quantified and the respective thematic maps were prepared on the basis of nutrient ratings.

Materials and Methods

Boranakunte-1 micro-watershed (13°55′42.21″ to 13°53′11.62″ N latitudes and 76°45′23.44″ to 76°44′28.08″ E longitudes) representing central dry zone (Zone-4) in Sira *taluk* of Tumkur district, Karnataka was selected for data base generation under batch VI Karnataka Watershed Development Programme-II (KWDP-II) of Sujala III project. The details of the study area and location map are given in fig. 1.

The cadastral map showing parcel boundaries was used as the base map. A grid of 250 m^2 spacing was overlaid on the cadastral map for the study. There were 140 grids in the micro-watershed covering an area of 939 ha. Out of total watershed area (TWA), cultivable land area is 912 ha. A total of 140 surface soil samples (0-15 cm) were collected along with GPS points from the respective grids using imagery or reference maps (Ten Lin- Liua *et al.* 2006). Samples were subjected to analysis of chemical and fertility parameters. The pH (1:2.5) and electrical conductivity (EC) of soils were measured using standard procedures as described by Jackson (1973). The available N (Subbiah and Asija 1956), available P (Olsen *et al.* 1954), available K (Hanway and Heidel 1952), organic carbon (Walkley and Black 1934), and available S (Chesnin and Yien 1951) contents were analyzed following the standard protocol. The contents of zinc (Zn), copper (Cu), manganese (Mn) and iron (Fe) were extracted with DTPA (Lindsay and Norvell 1978) and determined using atomic absorption spectrophotometer (AAS).

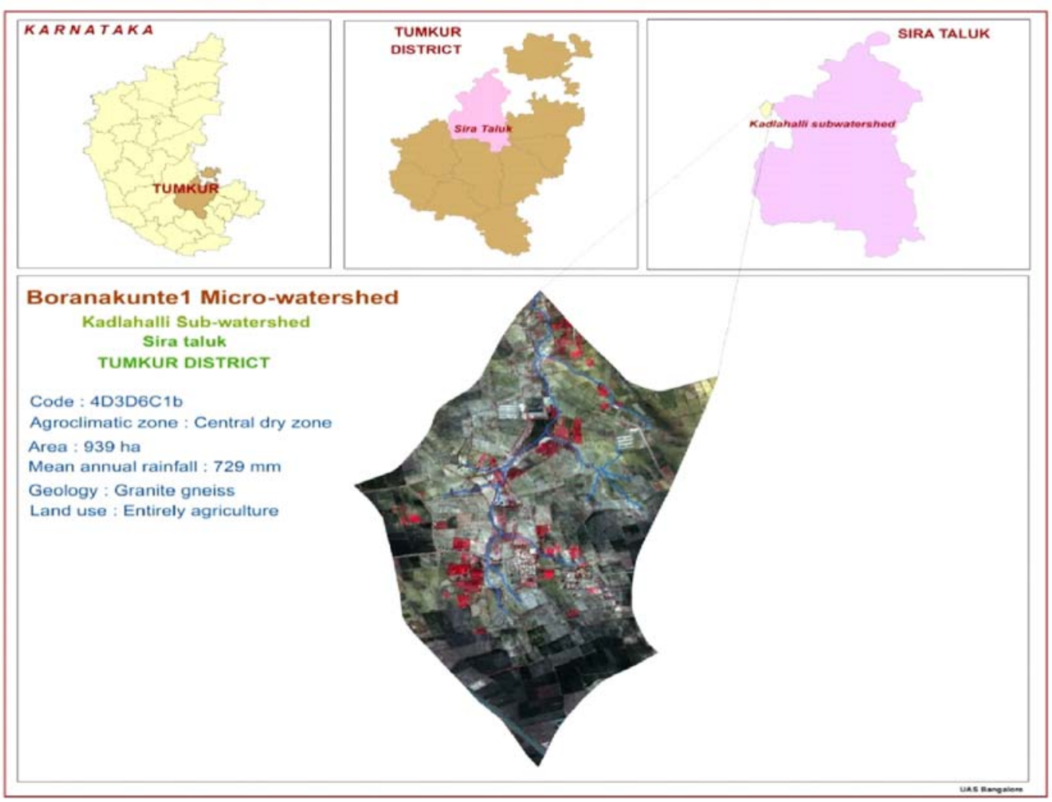

Fig. 1. Location map and details of Boranakunte-1 micro-watershed

Generation of thematic soil fertility maps

Database on soil available nutrient status was prepared using Microsoft Excel package and soil fertility maps were generated using geographic information system (GIS) ArcGIS software version 10.6. Base map of the Boranakunte Micro-watershed was digitized and geo-referenced. Polygons were superimposed on the geo-referred map. Latitude, longitude and analyzed soil data were entered into attribute table and linked to ArcGIS software for making thematic maps. The linear directional semi-variograms were constructed for the soil available micronutrients in spatial dependent models by plotting the semi-variance r (h) as a function of log between neighbouring observations. Inverse distance weighted interpolation was fitted to semi-variogram in order to create continuous surface for the estimated soil properties by using model fitting interface. Based on the percentage of nugget, spatial dependence classes were categorized in spatial variability map following standard soil fertility ratings (Table 1) by showing colour differences on the map (Ten Lin- Liua *et al.* 2006; Mirzaee *et al.* 2016).

Table 1. Soil fertility ratings for different parameters

Classes	Ratings		
Soil reaction (pH) classes			
Ultra acidic	<3.5		
Extremely acidic	3.5 - 4.5		
Very strongly acidic	4.5 - 5.0		
Strongly acidic	5.0 - 5.5		
Moderately acidic	5.5 - 6.0		
Slightly acidic	6.0 - 6.5		
Neutral	6.5 - 7.3		
Slightly alkaline	7.3 - 7.8		
Moderately alkaline	7.8 - 8.4		
Strongly alkaline	8.4 - 9.0		
Very strongly alkaline	>9.0		
Soil salinity classes (EC) (dS m^{-1})			
Non saline	<2		
Low	2 - 4		
Medium	4 - 8		
High	8 - 12		
Very high	12 - 16		
Extremely high	>16		
Available macronutrients classes	Low	Medium	High
Organic carbon (%)	<0.5	0.5 - 0.75	>0.75
Nitrogen (kg ha^{-1})	<280	280 - 560	>560
Phosphorus (kg P_2O_5 ha^{-1})	<23	23 - 56	>56
Potassium (kg K_2O ha^{-1})	<140	140 - 330	>330
Sulphur (mg kg^{-1})	<10	10 - 20	>20
Available micronutrients classes	Deficient		Sufficient
Copper (mg kg^{-1})	<0.2		>0.2
Iron (mg kg^{-1})	<4.5		>4.5
Manganese (mg kg^{-1})	<1.0		>1.0
Zinc (mg kg^{-1})	<0.6		>0.6

Results and Discussion

Soil reaction and electrical conductivity

Majority of soils in Boranakunte-1 micro-watershed were alkaline in reaction with a mean pH of 8.29 (Table 2). The soils were classified into slightly alkaline, moderately alkaline and strongly alkaline and among these moderately alkaline soils were dominant and covers an area of 480 ha (51.15% of TWA) followed by strongly alkaline (36.5% of TWA) (Table 3 and Fig. 2). The alkalinity of these soils mainly attributed to the calcareousness nature and prolonged dry spells. Most of the soils were low in salt content with a mean EC of 0.15 dS m^{-1} (Table 2).

Table 2. Mean value of different soil fertility parameters of Boranakunte-1 micro-watershed

Parameters	Mean	SD ±
pH (1:2.5)	8.29	0.47
EC (1:2.5) (dS m^{-1})	0.15	0.10
Organic carbon (%)	0.50	0.20
Nitrogen (kg ha^{-1})	238.9	48.8
Phosphorus (kg P_2O_5 ha^{-1})	31.6	13.3
Potassium (kg K_2O ha^{-1})	330.8	109.3
Sulphur (mg kg^{-1})	17.4	9.74
Calcium [cmol(p^+)kg^{-1}]	21.6	6.33
Magnesium [cmol(p^+)kg^{-1}]	10.8	3.35
Copper (mg kg^{-1})	0.90	0.32
Iron (mg kg^{-1})	2.91	0.80
Manganese (mg kg^{-1})	2.95	1.86
Zinc (mg kg^{-1})	0.46	0.20
Boron (mg kg^{-1})	0.6	0.25

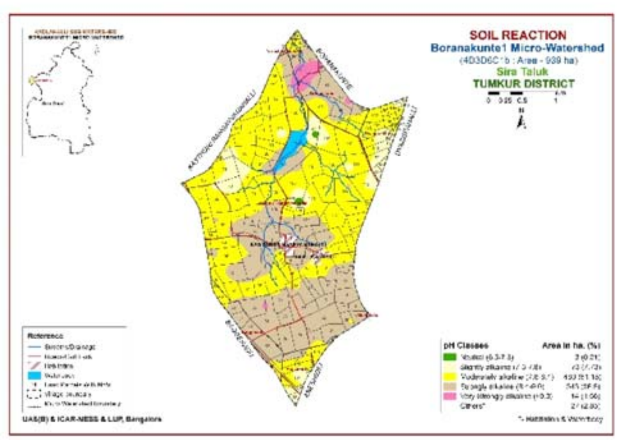

Fig. 2. Soil reaction

Table 3. Area distribution among different categories in Boranankunte-1 micro-watershed

Soil parameter	Category	Area (ha)	% of TWA
pH (1:2.5)	Neutral	2	0.21
	Slightly alkaline	73	7.73
	Moderately alkaline	480	51.1
	Strongly alkaline	343	36.5
	Very strongly alkaline	14	1.56
EC (1:2.5) (dS m^{-1})	Low	912	97.1
	Medium	-	-
	High	-	-
Organic carbon (%)	Low	464	49.5
	Medium	404	42.9
	High	44	4.7
Nitrogen (kg ha^{-1})	Low	912	97.1
	Medium	-	-
	High	-	-
Phosphorus (kg P_2O_5 ha^{-1})	Low	105	11.2
	Medium	804	85.6
	High	3	0.28
Potassium (kg K_2O ha^{-1})	Low	-	-
	Medium	457	48.6
	High	455	48.5
Sulphur (mg kg^{-1})	Low	101	10.7
	Medium	546	58.2
	High	265	28.2
Copper (mg kg^{-1})	Deficient	-	-
	Sufficient	912	97.1
Iron (mg kg^{-1})	Deficient	912	97.1
	Sufficient	-	-
Manganese (mg kg^{-1})	Deficient	-	-
	Sufficient	912	97.1
Zinc (mg kg^{-1})	Deficient	815	86.8
	Sufficient	97	10.4

TWA = Total Watershed Area

Organic carbon

The per cent OC in Boranakunte micro-watershed soils varied considerably with the mean value of 0.5% (Table 2). Soils with low OC status occupy 49.5% of total watershed area (TWA) followed by medium status which occupies an area of 42.3% of TWA (Table 3). Low to medium OC content in these soils is attributed to rapid rate of decomposition of organic matter due to high temperature and lack of addition of FYM and crop residues.

Available macronutrients

The available N status (Table 3 and Fig. 3) in soil was low (mean value of 238.9 kg ha^{-1}) in the entire micro-watershed area. Low available N could be attributed to less amount of OC in the soil as major portion of the N pool is contributed by organic matter (Prasuna Rani *et al.* 1992). The low rainfall and less vegetation cover coupled with faster mineralization and removal of organic matter might have lead to low available N.

The available P content were found low to high in the soils of Boranakunte-1 micro-watershed with a mean value of 31.6 kg ha^{-1} (Table 3, Fig. 4). Among these, available P is medium in an area of 85.6% of TWA (804 ha) followed by low available P in an area of 11.2% (105 ha) and remaining only 0.2% (3 ha) was found high in available P. The variation could be due to different crops grown and different management practices followed by farmers in the micro-watershed area.

The available K (Table 3, Fig. 5) was medium to high in soil with the mean value of 330.8 kg ha^{-1}. Approximately equal area was distributed between medium and high status in Boranakunte-1 watershed. This could be attributed to weathering, application of K fertilizers to different crops grown in micro-watershed and upward translocation of K from lower depth along with capillary raise due to low rainfall

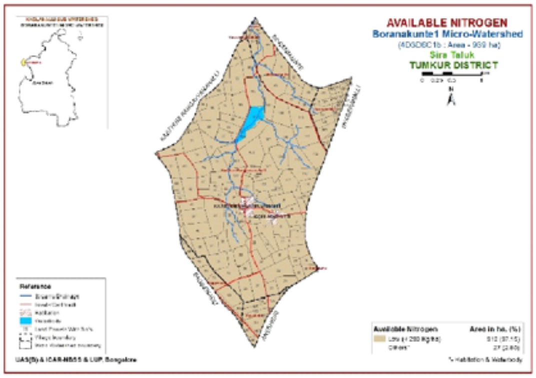

Fig. 3. Available nitrogen

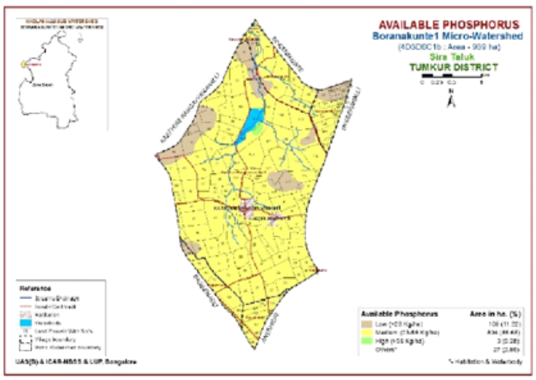

Fig. 4. Available phosphorus

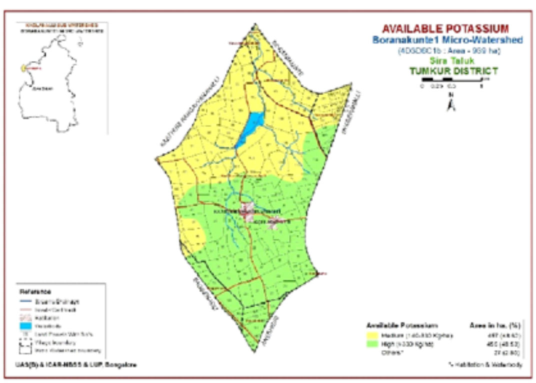

Fig. 5. Available potassium

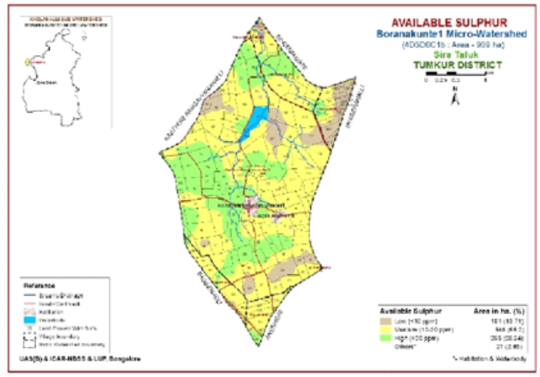

Fig. 6. Available sulphur

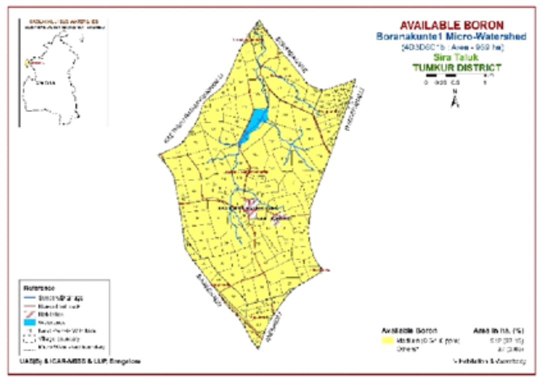

Fig. 7. Available boron

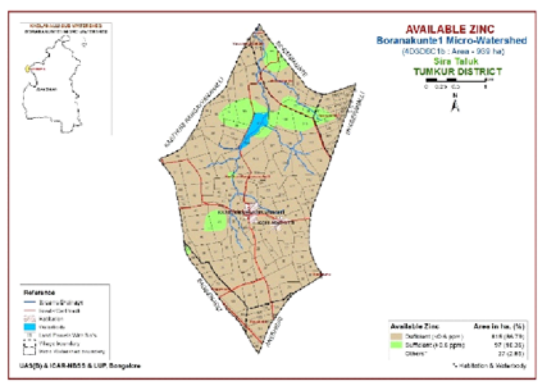

Fig. 8. Available zinc

and higher temperature. Similar results were reported by Ravikumar *et al.* (2007) in Malaprabha right bank command (MRBC) area of north Karnataka and Vara Prasad Rao *et al. (*2008) in Ramachandrapuram mandal of Chittoor district in Andhra Pradesh.

The available S status varied considerably in the soils of Boranakunte-1 micro watershed. It categorized in to low, medium and high status with the mean value of 17.4 mg kg^{-1} (Table 2, Fig. 6). It has been brought out more clearly from maps that 28.2% of TWA (265 ha) is high in available S, whereas 58.2% of TWA (546 ha) is found medium. Medium to high level of available S in soils of the study area may due to addition S to crops through single superphosphate (SSP) as majority of farmers are using SSP as source of phosphatic fertilizer (Balanagoudar 1989; Lavanya *et al.* 2019).

DTPA-extractable micronutrients

The DTPA extractable micronutrients *viz.,* Cu and Mn were found sufficient with the mean values of 0.90 and 2.95 mg kg^{-1}, respectively, while Fe and Zn were deficient with the mean values of 2.99 and 0.46 mg kg^{-1}, respectively (Table 2, Fig. 8 to 11). The

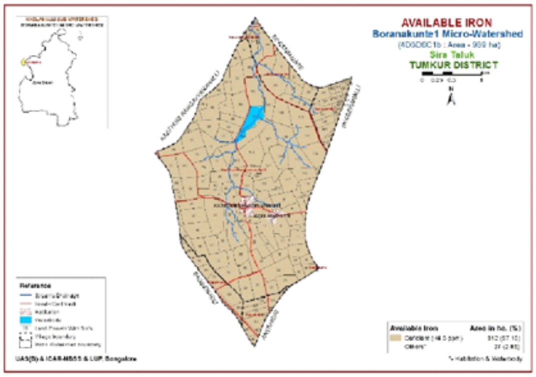

Fig. 9. Available iron

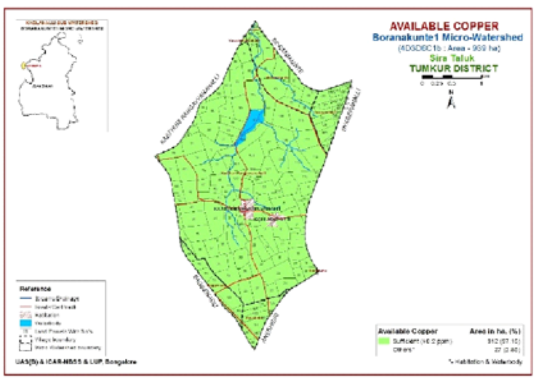

Fig. 10. Available copper

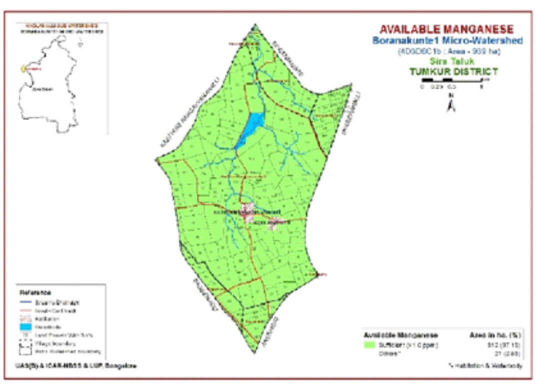

Fig. 11. Available manganese

available boron status was medium in the entire area with mean value of 0.6 mg kg^{-1} (Table 2, Fig. 7). The Zn status in 86.8% of TWA (815 ha) was below the critical level (Table 3, Fig. 8), while Fe deficiency was observed in 97.1% of TWA (912 ha). The deficiency of Zn and Fe in large area was attributed to decreased solubility and mobility due to alkaline reaction of the study area. These results are inconformity with the findings of Vijayashekhar *et al*. (2000). It may also due to non-application of Zn and Fe fertilizers.

Conclusions

The thematic maps generated using the survey data provide information regarding the aerial extent of different nutrient category soils. Using these information a sound and scientific nutrient management practices can be suggested to each parcel of land which would help in enhancing nutrient use efficiency, reducing input cost and improving the productivity of crops.

Acknowledgment

Authors acknowledge Watershed Development Department, Government of Karnataka and World Bank for providing financial support to carry out the study under Sujala-III project. The technical support provided by staff of Sujala is greatly acknowledged.

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Revised received 15 December 2020; Accepted 19 March 2021