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Sharanagouda SM
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Nagaraja MS
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Suma R
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Mandya, Karnataka, India

Prasanna SM
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Kantesh G
Department of Agronomy, College of Horticulture, Sirsi, Karnataka, India

Correspondence
Sharanagouda SM
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Micronutrient availability status among land categories irrigated with different water sources in Bilagi and Bagalkot Talukas

Sharanagouda SM, Nagaraja MS, Suma R, Prasanna SM and Kantesh G

Abstract
A survey study was conducted to know the micronutrient status of Bilagi and Bagalkot taluka. Surface soil samples (n=147) were collected from a grid of 4.5 x 4.5 km^2 and analysed for DTPA extractable micronutrients and factors influencing their availability pH and free $CaCO_3$ contents. DTPA extractable micronutrient contents varied among land categories depending on irrigation water sources. Majority of the soil samples representing dryland and borewell irrigated areas recorded lower availability range of micronutrients (except DTPA-Cu). Higher availability range was observed among irrigated land categories. In general, micronutrient availability was observed in the order of dryland < borewell = (canal + borewell) < lift = (lift + borewell) irrigated areas. Across different land categories, the concentration of DTPA micronutrients varied in the order Mn > Fe > Cu > Zn.

Keywords: Micronutrient, Black soils, dryland, free $CaCO_3$, pH, irrigated land, Karnataka

Introduction
Nutrient management is very important for successful crop production. In addition to nutrient management, availability also depends on soil, climate and cropping system. Nutrient availability plays important role in crop production and its availability depends on soil, climate, cropping system and management practices (Sharan Bhoopal Reddy *et al*, 2012) [11]. Deficiency of a nutrient not only induces abnormal growth and sometimes leads to complete failure of crop. Though the micronutrients required in smaller quantities, they are as important as macronutrients.
Micronutrient deficiency in northern Karnataka, especially in black soils, is most widespread. The soil properties are directly influenced by crop management and native soil properties. It may be largely attributed to exposed subsoils, presence of free CaCO3 (Nandi and Dasog, 1992) [7], low soil organic matter contents and high pH. The soil texture, presence of $CaCO_3$ and the extent of gravel content also determines the overall nutrient availability in a soil (Nagaraja *et al*, 2016) [4]. Considering these issues, a survey based study was carried out in black soils of Bilagi and Bagalkot talukas supplemented with different irrigation water resources.

Materials and methods
Study area: Biligi and Bagalkot talukas comes under northern dry zone of Karnataka and experiences sub- tropical climate with a characteristic semi – arid conditions where PET > RF. The mean annual temperature ranged from 30.2 to 32.6 ºC while, the mean annual rainfall of last 10 years average was 447.3 mm. The soils are mostly derived from basaltic parent material and large portions of the study area were observed under black soils belonging to vertisols.

Land categorization and soil sampling: Entire Bilagi and Bagalkot were divided into small grid units of 20.25 km^2 (4.5 x 4.5 km^2). Each grid was considered as a study unit and the details of dominant land use category were recorded. The entire study area were grouped into dryland (DL), Borewell irrigated (BW), Lift irrigated (Lift), Canal + Borewell irrigation (Canal + BW) and Lift + BW irrigation (Lift + BW) areas based on the source of irrigation. From each of the grid, surface soil samples (0 - 15 cm) were collected from 3 different points and made into one composite sample as a representative of that grid (Figure 1).

Soil analysis: The representative samples were analysed for soil pH (1:2.5 soil-water suspension) by pH meter; free $CaCO_3$ content by acid titration (Richards, 1954) and DTPA extrable micronutrients namely, Fe, Mn, Zn and Cu by feeding the extractant directly to MP - AES (Microwave Plasma - Atomic Emission Spectrophotometer). The soils were categorized into low, medium and high micronutrient availability based on the critical values given below. Finally, the data obtained were subjected to statistical tests such as single factor ANOVA; correlation descrptive analysis using MS-excel.

	Low	Medium	High
Iron (Fe)	< 2.5 ppm	2.5 – 4.5 ppm	> 4.5 ppm
Manganese (Mn)	< 2.0 ppm	2.0 – 4.0 ppm	> 4.0 ppm
Zinc (Zn)	< 0.6 ppm	0.6 – 1.5 ppm	> 1.5 ppm
Copper (Cu)	< 0.8 ppm	0.8 – 1.6 ppm	> 1.6 ppm

Result and discussion

The extent of DTPA- extractable available micronutrients in soils, in terms of their distributions and availability in soils are presented in Table-1 and Figure 2 respectively.

In terms of availability of iron (DTPA-Fe), more than 2/3rd of the samples analysed recorded higher range (> 4.5 ppm) while, only 6 samples (4.1 %) indicated lower availability (<2.5 ppm). Comparison among different land categories indicated that the soils representing dryland and borewell irrigated areas recorded low and medium Fe availability range. Contrastingly, majority of the soil samples from irrigated land categories recorded higher availability (Figure 1). Similar to DTPA-Fe, most of the soil samples recorded higher Mn-availability (n=132; 89.8 %). None of the samples recorded lower availability of Mn while, only a few samples representing dryland and borewell irrigated areas had medium range of DTPA-Mn.

In terms of DTPA-Cu, the extent of soil samples under low, medium and high categories were almost similar to that of Fe and Mn distribution. Majority of the samples (n=122; nearly 85 %) were found in higher range while, only 25 samples were observed with lesser availability. None of the irrigated soil samples were found in lower range. In contrast to DTPA-Fe, Mn and Cu, the DTPA-Zn contents were observed in medium range (0.6-1.5 ppm) in nearly 60 % of the samples and it was found in lower range (< 0.6 pppm) in 18 % of the samples. Higher Zn-availability range was observed only in 1/4th of the samples representing borewell and lift irrigation areas.

The amounts of DTPA extractable individual micronutrients (Fe, Mn, Zn and Cu) among different land categories varied significantly (Table 1). In general, amounts of available micronutrients (Fe, Mn, Zn and Cu) were found significantly low in dryland soils (without irrigation). However, all of them increased with irrigations. Among irrigated land categories, all the 4 categories recorded higher amounts and they varied to different extents. The land areas irrigated with lift water alone or lift + borewell water together recorded significantly higher values in most of the nutrients (Figure 1). However, the areas irrigated with borewell alone or borewell with canal water recorded moderate amounts. In general micronutrient availability was observed in the order of dryland < borewell = (canal + borewell) < lift = (lift + borewell) irrigated areas. Across different land categories, the concentration of DTPA micronutrients varied in the order Mn > Fe > Cu > Zn.

The variations in micronutrient availability among different irrigation sources may be attributed to the direct effects of pH and CaCO3 on solubility and precipitation reactions (Lindsay, 1991) [11]. The soil minerals tend to stay in respective hydroxides at higher pH and thus, the release of nutrients through solubilisation decreases (Pulakeshi *et al*., 2012) [8]. Varied amounts of $CaCO_3$ in soils also might have altered soil pH and hence, micronutrient availability (Shivakumar *et al*, 2016; Rekha *et al*, 2015) [12, 9]. The alkaline pH in these black soils may be attributed to higher free $CaCO_3$ contents (Anita *et al*, 2018) [1] as they are mostly derived from lime parent material (Doddamani, 1994) [3]. They are generally observed in the form of small white lime crystals and shows effervescence with addition of dilute mineral acids.

The metal ions remain as respective hydroxides at higher pH and there by their availability decreases (Lindsay, 1991) [5]. Negative correlations between soil pH and micronutrients availability (Table 2) are also in concurrence with reduced availability under alkaline conditions (Vasuki, 2010; Kirankumar *et al*, 2016) [13, 4]. Variations in DTPA-extractable micronutrient contents may be attributed to alteration in soil pH (Table 2). The solubility of iron bearing minerals and hence, its availability is largely influenced by soil pH (Lindsay, 1991) [5]. Occurrence of higher amounts of carbonates and bicarbonates in both dryland areas and borewell irrigated areas might have reduced iron availability (Vijayshekar *et al*., 2000) [14]. Anaerobic conditions prevailing in micro-environments under irrigated conditions might have enhanced Fe and Mn availability (Arora and Shekon, 1981) [2]. Lower availability of DTPA-Zn in dryland areas may be attributed to precipitation of Zn as zinc oxides or hydroxides during alternate wetting and drying cycles (Pulakeshi *et al*., 2012) [8]. Similar observations on reduced micronutrient availability under moderate to highly alkaline soil pH are also reported by Kirankumar *et al*. (2016) [4], Rekha *et al*, (2015) [9] and Yogeeshappa *et al*. (2007) [15] The order of DTPA extractable micronutrients in the soil order Mn > Fe > Cu > Zn may be attributed to the mineralogical composition of basaltic minerals from which these black soils are formed (Nandi and Dasog, 1992) [7].

Table 1: Magnitude of DTPA- extractable micronutrients among different land categories based on irrigation water sources.

Land category based on irrigation sources	Range (ppm)	Mean ± SD (ppm)
DTPA Extractable - Fe		
Dry land (no irrigation) (n = 32)	1.10 to 10.92	4.73 ± 1.72 b
Borewell Irrigation (n = 88)	1.91 to 10.08	5.15 ± 1.66 b
Lift Irrigation (n = 13)	5.01 to 9.52	6.98 ± 1.51 a
Canal + Borewell Irrigation (n = 6)	3.71 to 8.35	5.68 ± 1.60 ab
Lift + Borewell Irrigation (n = 8)	3.28 to 7.85	5.30 ± 1.61 b
DTPA Extractable - Mn		
Dry land (no irrigation) (n = 32)	2.31 to 12.43	6.14 ± 2.57 b
Borewell Irrigation (n = 88)	2.92 to 18.51	9.13 ± 3.87 a
Lift Irrigation (n = 13)	4.91 to 11.87	8.62 ± 2.08 a

Canal + Borewell Irrigation (n = 6)	5.98 to 10.59	8.21 ± 1.68 [ab]
Lift + Borewell Irrigation (n = 8)	5.64 to 10.19	7.98 ± 1.41 [ab]
DTPA Extractable - Zn		
Dry land (no irrigation) (n = 32)	0.39 to 0.99	0.58 ± 0.16 [c]
Borewell Irrigation (n = 88)	0.49 to 3.55	1.25 ± 0.39 [b]
Lift Irrigation (n = 13)	0.71 to 3.31	2.26 ± 0.63 [a]
Canal + Borewell Irrigation (n = 6)	0.56 to 1.46	1.10 ± 0.32 [b]
Lift + Borewell Irrigation (n = 8)	1.80 to 3.56	2.53 ± 0.64 [a]
DTPA Extractable - Cu		
Dry land (no irrigation) (n = 32)	0.43 to 3.26	1.63 ± 0.65[c]
Borewell Irrigation (n = 88)	0.99 to 4.85	2.57 ± 0.83[b]
Lift Irrigation (n = 13)	1.04 to 5.12	3.20 ±1.11[a]
Canal + Borewell Irrigation (n = 6)	1.06 to 3.10	2.37 ± 0.88[b]
Lift + Borewell Irrigation (n = 8)	1.85 to 4.97	3.37 ± 0.86[a]

Table 2: Correlation coefficients of soil parameters and DTPA – micronutrients

	pH	$CaCO_3$
DTPA-Fe	0.096	- 0.049
DTPA-Mn	- 0.115	- 0.234*
DTPA-Zn	- 0.216**	- 0.239**
DTPA-Cu	- 0.218**	- 0.031

* - Significance at 5% level; ** - Significance at 1% level

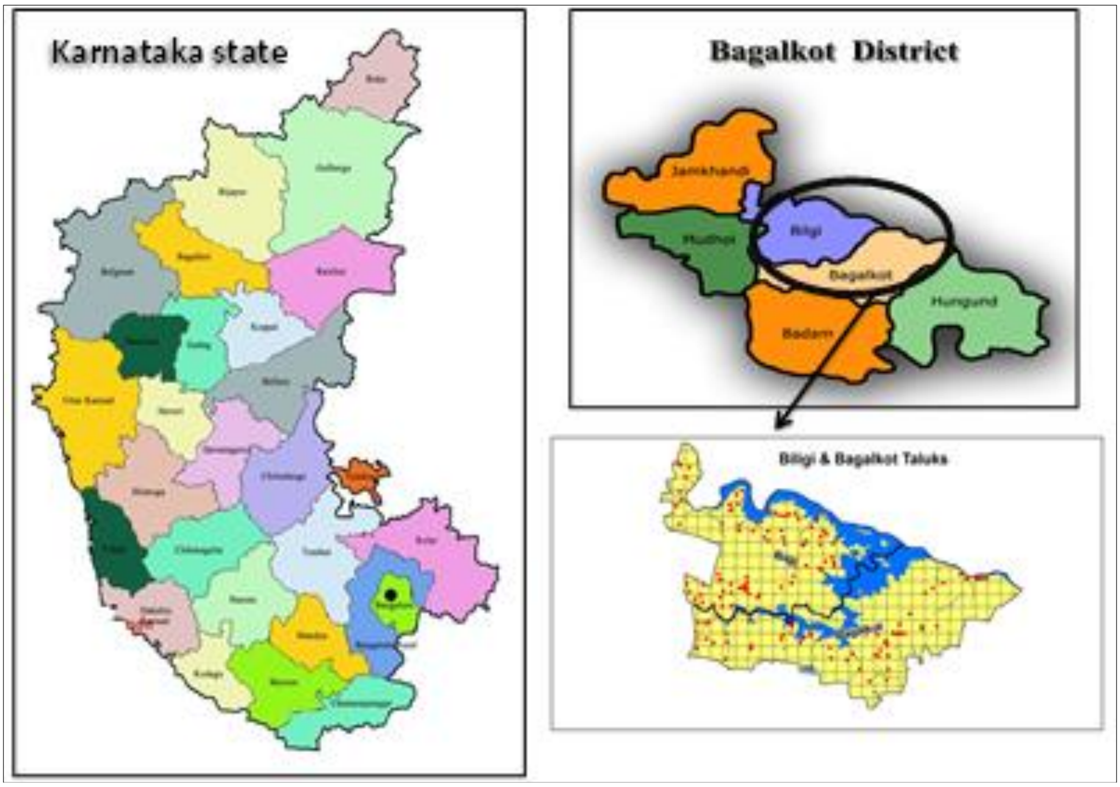
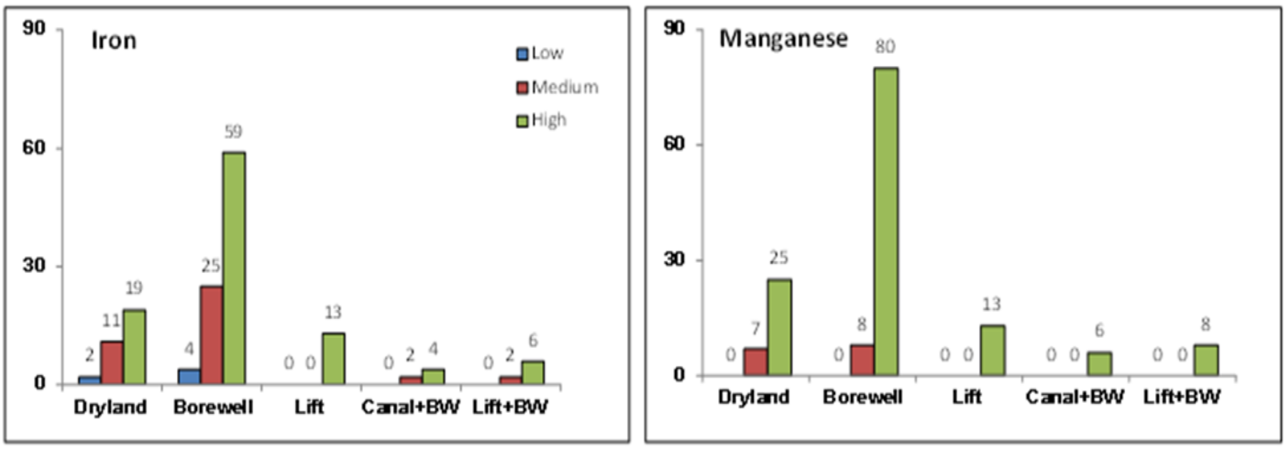


Fig 1: Location map of the study area



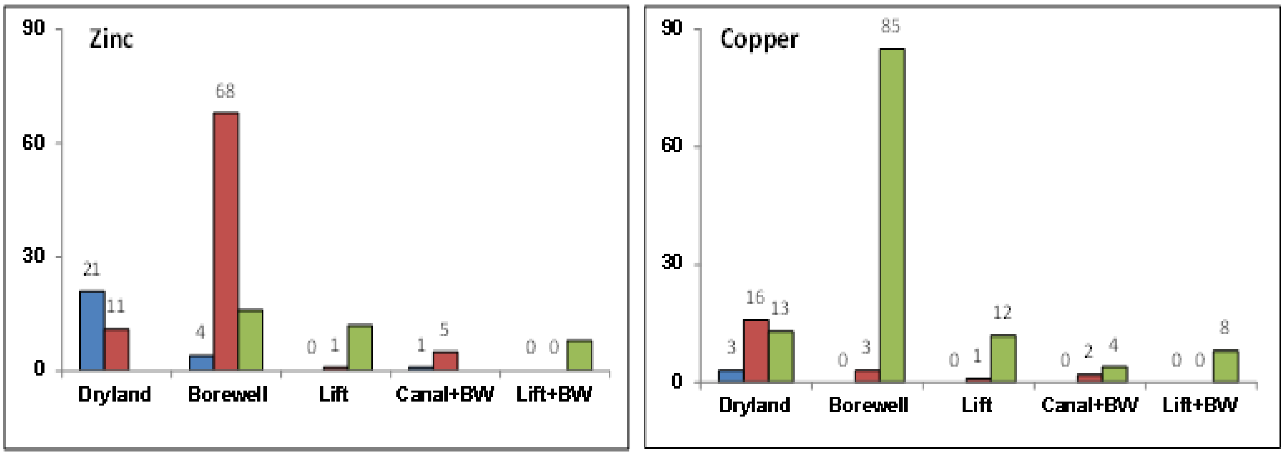


Fig 2: Extent of DTPA available micronutrients (ppm) among different land categories based on irrigation water sources in Bilagi and Bagalkot talukas

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