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# AVAILABILITY OF MICRONUTRIENTS AMONG DIFFERENT CROPPING SYSTEMS IN A TYPICAL BLACK SOIL OF NORTHERN KARNATAKA

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## ABSTRACT
Surface composite soil samples were collected from different cropping systems were analysed for DTPA extractable micronutrients and the soil factors determining their availability namely. pH, free $CaCO_3$ and soil organic–C. The DTPA- micronutrients varied significantly among 3 major cropping systems and it was found in the order: sugarcane > maize/groundnut-onion > cereal-pulse systems. All the micronutrients indicated negative correlations with soil pH and the variations in soil pH as determined by free $CaCO_3$ contents. A significant and positive correlation was observed between pH and $CaCO_3$ contents. The soil organic carbon was found positively correlated with DTPA-Mn content. Higher availability of micronutrients in sugarcane cropping system compared to others was in conformity with the above soil factors.

## INTRODUCTION

Indian agriculture has achieved a fourfold increase in food production during the last half century by adopting modern agricultural practices. This achievement was possible due to cultivation of fertilizer responsive HYV of major cereals along with use of N and P fertilizers. Application of urea and DAP could alone made us to achieve initially as soil could provide all other essential plant nutrients. However, the nutrient reserves in soil got exhausted gradually in few years and it was no longer possible to sustain higher yields with N and P alone (Katyal and Randhawa, 1983; Singh *et al.*, 2009). Thus, the drive for targeting higher agricultural production needed balanced use of nutrients which otherwise create problems of soil fertility exhaustion and nutrient imbalances not only of major but also of secondary and micronutrients. Today, crops grown in about half of the country's soils suffer from one or more micronutrient disorders (Patel and Singh, 2009). Intensive cropping systems with high yielding varieties and decreased FYM applications only lead to exhaustion of micronutrients from the soil bank (Katyal and Randhawa,1983).

These micronutrients are required in relatively smaller quantities for plant growth and they are as important as macronutrients. Deficiency of micronutrients results in abnormal growth, which sometimes cause complete crop failure. Most of micronutrients are associated with the enzymatic system of plants. Thus, micronutrient deficiency and toxicity can reduce plant yield (Brady and Weil, 2008). However, flower formation of flowers and development of grains do not take place in severe deficiencies (Manasa *et al.*, 2015). The availability of micronutrient to plant growth is particularly sensitive to change in soil environmental factors like organic matter, soil pH, lime content and soil texture (Nadaf *et al.*, 2015; Lalithya *et al.*, 2014).

The black soils of northern Karnataka belonging to Vertisols. Drought being the foremost constraint across northern dry zone of Karnataka, the soils developed in such an environment possess free $CaCO_3$ (1-50%), high pH (>7.0–8.5) and low organic matter (<1%) (Fragaria *et al.*, 2002; Ravikumar *et al.*, 2007; Nadaf *et al.*, 2015). Consequently, nutrient disorders in these soils are the most important limiting factor to crop production, second only to moisture stress. Though the major constraints are deficiencies of nitrogen and phosphorus, research in the recent past has revealed that micronutrient problems also hamper crop production (Keram *et al.*, 2014). Micronutrient deficiency is most widespread due to soil chemical factors namely exposed subsoils, low organic matter contents, calcareousness, alkaline soil pH, irrigation induced soil electro-chemical changes and use of pure fertilizers. Unlike major nutrient deficiencies, micronutrient problems are highly crop and location-specific. Deficiency of micronutrients could be significant particularly in Bagalkot district. However, there is very little information available for the District. Therefore, the objective of the present study was to assess the status of micronutrients (Mn, Fe, Cu and Zn) in Vertisols cultivated with different cropping systems.

## MATERIALS AND METHODS

A survey based study was conducted in a typical black soil of Northern Karnataka at Mudhol Taluka of Bagalkot district during 2014-15. The study area was divided into smaller units with grids of 2.25 × 2.25 $km^2$ and identified as a sampling unit. The dominant cropping system in each grid namely, sugarcane, maize/groundnut-onion and cereal-pulse systems for soil study. The surface soil samples (0-15 cm) were collected in 3 replications and made it into one composite sample as a representative of the grid. The soil samples were air dried, sieved (2mm) and stored for further analysis.

The processed soil samples were analysed for soil pH, organic carbon, free $CaCO_3$ and DTPA extractable micronutrients. The pH was determined by potentiometric method for 1:2.5 soil : water suspension using Systronics (Model 361) pH meter (Jackson, 1973). The soil organic-C was determined by wet oxidation method as described by Walkley and Black (1934) and free $CaCO_3$ content was determined by acid titration (Nelson, 1982). The soil micro nutrients *viz*. Fe, Mn, Zn and Cu were extracted using DTPA and determined by using Thermofischer Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). Finally, these observations were also subjected to suitable statistical tests for further interpretations.

## RESULTS AND DISCUSSION

The amount of DTPA-Fe present in black soils of Mudhol taluka ranged from 2.52 to 8.80 ppm (Table 1). Nearly 2/3rd of samples analysed (73.42 %) were found with higher range (> 4.5 ppm) of DTPA-Fe. while, 26.57 % of the samples recorded medium levels (2.5 - 4.5 ppm). Sugarcane cropping system had significantly higher amounts of DTPA-Fe with a mean value of 5.52 ± 1.59 ppm and it was on par with maize / groundnut - onion cropping system (5.22 ± 1.06 ppm). However, dryland based cereal – pulse cropping area recorded lesser amounts of DTPA-Fe (4.96 ± 1.07 ppm). The DTPA-Mn ranged from 2.24 to 17.42 ppm and both of them were observed in sugarcane cropping systems. More than 95 per cent of soil samples (n = 137) recorded higher DTPA- Mn (>4.00 ppm). The DTPA-Mn varied significantly among different cropping systems and it was found in the order: sugarcane > maize / groundnut - onion > cereal-pulses with 8.98 ± 3.19 ppm, 7.21 ± 3.68 ppm and 5.73 ± 2.69 ppm of DTPA-Mn respectively.

The DTPA- Zn and Cu in these soils ranged from 0.11 to 5.61 ppm and 0.80 to 7.21 pm respectively. Majority of the soils were observed in medium (56.64 %) and higher (30.76 %) range of DTPA-Zn contents. With respect to DTPA – Cu, nearly 86.72 per cent of soil samples were in higher range (>1.6 ppm) and 13.28 per cent were in medium range (0.8-1.6 ppm). In terms of cropping systems, the availability of zinc and copper differed significantly in the order: sugarcane = maize / groundnut - onion > cereal- pulse cropping systems.

The variations in DTPA extractable micronutrients among different cropping systems may be attributed to the effects of soil factors such as pH, $CaCO_3$ and SOC (Lindsay, 1991; Brady and Weil, 2008). The influence of soil pH on the solubility of minerals and the availability of micronutrients are also reported by Verma *et al.* (2005) and Pati and Mukhopadhyay (2011).

**Table 1: DTPA-extractable micronutrients among different cropping systems**

| Cropping System | | Number of samples representing different availability status (in ppm) | | | Mean ± SD(in ppm) |
|---|---|---|---|---|---|
| | | Low | Medium | High | |
| DTPA extractable – Fe | | < 2.50 | 2.50 – 4.50 | > 4.50 | |
| Cereal-Pulse | (n = 16) | 0 | 6 (4.19) | 10 (6.99) | 4.96 ± 1.07$^{a}$ |
| Maize/g. nut – Onion | (n = 5) | 0 | 2 (1.39) | 3 (2.09) | 5.22 ± 1.06$^{ab}$ |
| Sugarcane | (n = 122) | 0 | 30 (20.97) | 92 (64.32) | 5.52 ± 1.59$^{b}$ |
| Total and statistics | | 0 | 38 (26.57) | 105 (73.42) | Cal. F = 0.98; $P_{0.05}$ = 0.52 |
| DTPA extractable – Mn | | < 2.00 | 2.00 – 4.00 | > 4.00 | |
| Cereal-Pulse | (n = 16) | 0 | 3 (2.09) | 13 (9.09) | 5.73 ± 2.69$^{a}$ |
| Maize / g.nut – Onion | (n = 5) | 0 | 1 (0.69) | 4 (2.79) | 7.21 ± 3.68$^{b}$ |
| Sugarcane | (n = 122) | 0 | 2 (1.39) | 120 (83.91) | 8.98 ± 3.19$^{c}$ |
| Total and statistics | | 0 | 6 (4.19) | 137 (95.80) | Cal. F = 7.98; $P_{0.05}$ = 1.09 |
| DTPA extractable – Cu | | < 0.80 | 0.80 – 1.60 | > 1.60 | |
| Cereal-Pulse | (n = 16) | 0 | 9 (6.29) | 7 (4.89) | 1.70 ± 0.92$^{a}$ |
| Maize / g.nut – Onion | (n = 5) | 0 | 1 (0.69) | 4 (2.79) | 2.78 ± 1.03$^{b}$ |
| Sugarcane | (n = 122) | 0 | 9 (6.29) | 113 (79.01) | 3.00 ± 0.97$^{b}$ |
| Total and statistics | | 0 | 19 (13.28) | 124 (86.71) | Cal. F = 12.66; $P_{0.05}$ = 0.33 |
| DTPA extractable – Zn | | < 0.60 | 0.60 – 1.50 | > 1.50 | |
| Cereal-Pulse | (n = 16) | 9 (6.29) | 6 (4.19) | 1 (0.69) | 0.62 ± 0.33$^{a}$ |
| Maize / g.nut – Onion | (n = 5) | 1 (0.69) | 2 (1.39) | 2 (1.39) | 1.67 ± 1.20$^{b}$ |
| Sugarcane | (n = 122) | 8 (5.59) | 73 (51.04) | 41 (28.66) | 1.38 ± 0.92$^{b}$ |
| Total and statistics | | 18 (12.58) | 81 (56.64) | 44 (30.76) | Cal. F = 5.70; $P_{0.05}$ = 0.30 |

Note: 1. Values in parenthesis depict per cent values of sample numbers; 2. Different letters in mean column imply significant differences at P d" 0.05

**Table 2: Correlation coefficients of soil parameters and DTPA - micronutrients**

| | pH | $CaCO_3$ | SOC | DTPA-Fe | DTPA-Mn | DTPA-Zn | DTPA-Cu |
|---|---|---|---|---|---|---|---|
| pH | 1.000 | | | | | | |
| $CaCO_3$ | 0.357* | 1.000 | | | | | |
| SOC | 0.040 | -0.044 | 1.000 | | | | |
| DTPA-Fe | -0.190* | -0.260** | 0.062 | 1.000 | | | |
| DTPA-Mn | -0.168* | -0.194** | 0.351** | 0.017 | 1.000 | | |
| DTPA-Zn | -0.177* | -0.198** | 0.096 | -0.025 | 0.171* | 1.000 | |
| DTPA-Cu | -0.181* | -0.334** | 0.087 | 0.340** | 0.181* | 0.183* | 1.000 |

Note:* values significant at P d” 0.05 level; and ;** Values significant at P d” 0.01 level

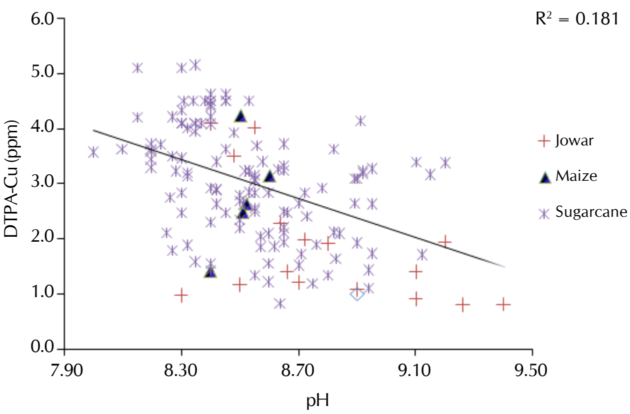


**Figure 1: Relationship between soil pH and DTPA-Copper (ppm)**

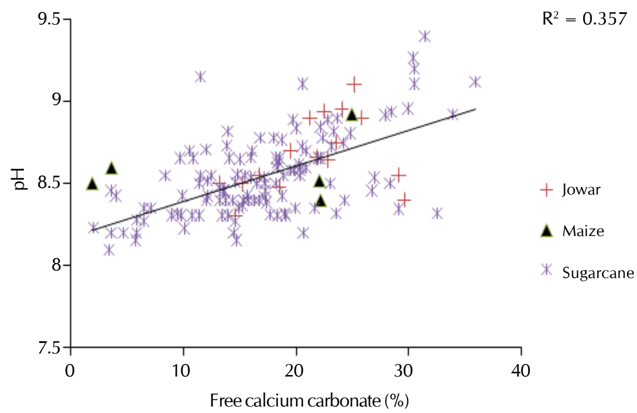


**Figure 2: Relationship between soil pH and free Calcium carbonate ($CaCO_3$ in %)**

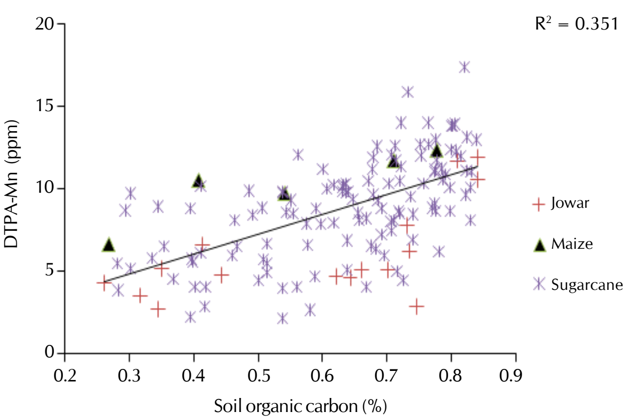


**Figure 3: Relationship between soil organic carbon (SOC %) and DTPA-Mn (ppm)**

The metal ions remain as respective hydroxides at higher pH and thereby their availability decreases (Lindsay, 1991). Negative correlations between soil pH and micronutrients availability (Table 3 and Fig. 1) are also in concurrence with reduced availability under alkaline conditions (Somasundaram *et al.*, 2009; Vasuki, 2010). Similar observations on low availability of micronutrients in alkaline and calcareous soils have been made (Singh *et al.*, 1988; Singh *et al.*, 2011).

The alkaline pH in these black soils are largely due to occurrence of high amounts of free $CaCO_3$ as these soils are mostly derived from lime based parent material (Doddamani, 1994). They are generally observed in the form of small white lime crystals and shows effervescence with addition of dilute mineral acids. Low micronutrient availability in these soils are further confirmed by a positive correlation between pH and free $CaCO_3$ contents (Table 3; Fig. 2). Similar interactions in black soils of Karnataka have been reported by Ravikumar *et al.*, 2007 and Kirankumar *et al.*, 2015.

The complexation of micronutrients with organic acids (Venkatesh *et al.*, 2003; Lindsay, 1991) and release of $H^+$ ions during organic matter decomposition (Sharma and Chaudhary, 2007) might have enhanced micronutrient availability. However, the positive effect of soil organic matter was found significant only with DTPA- Mn (Table 3; Fig. 3). Thus, higher availability of micronutrients in sugarcane cropping systems over others may be attributed to the changes in soil properties as influenced by irrigation practices, high dose of fertilizers applications and high biomass turnovers (Takkar, 1996; Venkatesh *et al.*, 2003; Vasuki, 2010).

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